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DEVELOPMENT
OF
GEOTHERMAL RESOURCES

MASTER PLAN

Kahauale'a

MASTER PLAN
FOR
EXPLORATION & DEVELOPMENT OF GEOTHERMAL RESOURCES

Kahauale'a Geothermal Project
Puna District, Island of Hawaii

Prepared by:

True/Mid-Pacific Geothermal Venture in Coordination with
the Trustees of the Estate of James Campbell

Submitted to:

State of Hawaii, Department of Land & Natural Resources

February 1982

TRUE/MID-PACIFIC GEOTHERMAL VENTURE

Master Plan

for

The Kahauale'a Geothermal Project

Prepared by

True Geothermal Energy Company and
Mid-Pacific Geothermal, Inc. for
submission to the Board of Land
and Natural Resources, State of
Hawaii in coordination with the
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PREFACE

The State of Hawaii is one of the few states in America which appears to have the potential to become energy self sufficient with renewable resources. Governor George Ariyoshi has proclaimed this goal for the State and is acting on many fronts towards achieving its accomplishment with the cooperation and assistance of governmental and private organizations and the citizens of Hawaii. It is a task of major proportions involving considerable investment of capital over a substantial period of time. The means applied to achieve this goal must be carefully planned, reflect a conscious awareness for the interests and concerns of the people of the State, and be effective in execution. The end results can not only reduce or eliminate Hawaii's near total dependence on imported energy, but can be of major and lasting social and economic benefit to the State and its communities.

Geothermal energy can contribute significantly towards achieving Hawaii's energy self-sufficiency goal. All indications are that the geothermal resource potential within the State is significant and the technology is available or being developed to assure that the resources can be located and converted efficiently into electrical power or used directly in the form of the steam, heat, and water, for myriads of rapidly developing applications involving food processing, sugar production, fertilizer and cattle feed production, agriculture and aquaculture. Moreover, it is expected that the residue of geothermal resources not otherwise used can be converted into useful by-products that are

needed in the State. Equally important, the large scale conversion of geothermal resources into energy or by-products can be accomplished without unacceptable negative impacts on the physical environment or the social structure or standards of the community.

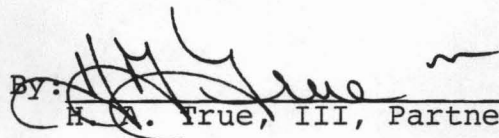
Economic benefits will accrue to the community from the development and marketing of the energy from geothermal resources and by-products by curtailing vast out-of-state and out-of-country dollar expenditures from Hawaii for imported energy resources and by redirecting those expenditures within the State for the development and purchase of local, renewable energy resources. These "retained" dollars together with the attendant investments and new business activities directly involved in alternate energy development and production will contribute to expanding the job market in Hawaii not only in numbers, but in the quality and variety of career opportunities that will become available to the work force in Hawaii. In addition, the dramatically escalating costs of electrical energy due to oil pricing policies of OPEC countries can now be realistically challenged in Hawaii through the development of renewable energy resources and the competitive market processes that will follow among the alternate energy suppliers. The developers have concluded that geothermally generated energy can be competitive with all other alternate energy sources, and can produce energy cheaper than oil-generated power at current oil prices, thereby ameliorating the predicted future increases in the cost of producing energy.

It is the objective of True Geothermal Energy Company and Mid-Pacific Geothermal, Inc., in coordination with the Estate of

James Campbell, to participate with the State and its citizens in this important and challenging goal set by the Governor. Towards this end, we have prepared this Master Plan to document the approach we propose in the discovery and development of geothermal resources on the property of the Campbell Estate, in Puna, Hawaii. We feel confident that this plan, together with the supporting Environmental Impact Statement, properly addresses the concerns of the citizens of this state with respect to the impact of geothermal development and demonstrates that its implementation will be in full compliance with applicable laws and regulations.

As energy developers, we will be diligent in the exercise of our responsibility for the care and preservation of the land on which we operate and the efficient use of its underground geothermal resource.

TRUE GEOTHERMAL ENERGY COMPANY

By: 
H. A. True, III, Partner

MID-PACIFIC GEOTHERMAL, INC.

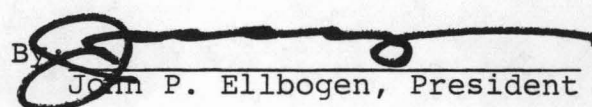
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** By separate distribution

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EXECUTIVE SUMMARY

This Master Plan for Development of Geothermal Resources has been prepared to support a Conservation District Use Application (CDUA) and request for a Geothermal Mining Lease to mine and market such resources on conservation land (Kahauale'a) owned in fee by the Estate of James Campbell and located in the Puna District, Island of Hawaii. This plan has been prepared by True/Mid-Pacific Geothermal Venture, developer and prospective sub-lessee of the mining lease for the foregoing property in coordination with the Trustees of the Estate of James Campbell.

The Master Plan is a model of our projections of the exploration and development operations that we expect to occur in fully developing the geothermal resource potential of the Kahauale'a parcel in response to a developing market. It has been calculated that the Kahauale'a parcel can potentially produce up to 250 megawatts of electrical power (MWe) from geothermal resources plus an undetermined amount of residual hot water and steam for direct use applications.

The initial objectives of this project are to prove the existence of a geothermal resource, its characteristics, and whether it can be economically produced and marketed. Subsequent exploration and development, in parallel with additional market development, will help determine the extent of the producible resource underlying the Kahauale'a parcel, the rate of development and whether the planned scope of the project can be realized.

The development concept of the Master Plan is designed to alternate exploration and development (production) drilling within the Kahauale'a parcel. Upon proving through exploration and confirmation drilling the existence of resources sufficient to supply an existing or contracted for demand, development drilling (i.e., drilling of "step-out" wells) will be conducted until that demand is satisfied.

The exploration, development and marketing activities described in the Master Plan will be executed over a period of 14 to 20 years depending on the extent and quality of the resource and the development of suitable markets to utilize the resource. The principal activities during the initial stages of the development effort consist of:

- exploration and development drilling to compete for the current projected electrical power market of Hawaii Electric Light Company (HELCO).
- additional exploration drilling to extend the areas of proven geothermal resources.
- additional development drilling to meet additional existing or potential market demands.

It is estimated that twenty successful exploration wells will have to be drilled to prove that up to 250 MWe of power can be produced from the Kahauale'a parcel. Therefore, during the initial development activity, a portion of this overall exploration objective will be accomplished consistent with the prospects for proceeding with the undersea cable project or such other markets as may be identified.

There are thirty-five planned drilling sites in selected areas of the exploration and development zones projected to have high and moderate resource potential. Selection of additional drilling sites within the leased area will be based on the results of all previous drilling on the property. It is contemplated that drilling operations will be conducted on an ongoing basis. The drilling rate is projected at 6 wells per year with an average success rate of 4 wells per year.

After an initial discovery, one or more confirmation wells will be drilled to verify the presence of a reservoir capable of economical production, to gain additional information on its dimensions and characteristics and to facilitate well testing between the wells drawing from a common reservoir. All wells will be flow tested under controlled conditions. Some venting of geothermal steam to the atmosphere will occur during the testing period and subsequently during normal operations. Appropriate measures for emission and noise abatement will be taken.

A "gathering system" consisting primarily of pipelines to transmit the hot geothermal brine from the production wells to an electric power plant and to return cooled fluid to a reinjection well will be constructed, where practical, adjacent to the roads connecting well sites with power plants (or other consumer facility).

It is planned that processed geothermal fluids which cannot be disposed of on the surface after treatment will be reinjected into a completely enclosed and sealed well bore to a depth that will assure it will not disturb any potable basal water lens. One injection well is planned for every three production wells.

The scope of the project encompasses the construction of power plants to convert the geothermal energy into electricity. There are five power plant sites tentatively located for the project within one to two miles of prospective drilling sites, except where volcanic hazards dictate further separation between the well and power plant. Design of the power plants cannot be initiated until analysis of the resource and flow testing of several wells is accomplished to obtain basic reservoir engineering data and to determine whether commercial production is technically and economically feasible. The Master Plan describes both a 25 MW and 110 MW plant and their operation to enable evaluation of the smallest and largest operating systems proposed for the project.

Right-of-way for transmission lines to transport the electrical power from the switching station within Kahauale'a to connect with HELCO's main distribution lines is the responsibility of HELCO. Transmission lines for the first 25 MW of power are expected to parallel existing roads. Routes for transmission lines for large power requirements for export via

undersea cable cannot be determined until the extent and location of geothermal resources in the Puna area are known.

Drilling operations will be conducted by the operator, True Geothermal Energy Company. It is anticipated that most construction operations will be contracted through local companies.

Traffic into the Kahauale'a parcel will be controlled by a gate at the entrance together with such safety and security patrol activity as may be required for the drilling and construction operations within the property. The land owner will institute a land management plan to extend the control necessitated by opening of a road into this parcel.

After the initial exploration objectives of the project are realized, project activity will consist primarily of development drilling to satisfy expanding market requirements. Additional exploration drilling would be conducted to prove the existence of such additional reserves as may be required to supply a portion of the electrical power demand for an undersea transmission cable and to further demonstrate the resource potential of the property.

Environmental base line data has been obtained and evaluated on the basis of the Master Plan to fully develop the estimated geothermal potential of the property. Similarly, the environmental impact statement, including the sociologic and economic impact, is based on the full development scenario as

reflected in this plan. The environmental impact assessment of the proposed development has been determined to be minimal under the measures of control and monitoring that will be exercised.

It is evident that within the scope of the project the principal market being projected for geothermal resources is in producing electrical power and the Master Plan provides for power plants as an element of the project.

TRUE/MID-PACIFIC GEOTHERMAL VENTURE

Master Development Plan

for

The Kahauale'a Geothermal Project

1.0 PURPOSE

This master development plan describes the scope of operations planned for the exploration, development and marketing of geothermal resources as provided for in applicable regulations. Thus, it is intended to assist all governmental agencies having responsibilities and authority relative to geothermal mining operations land use and environmental quality in assessing the scope of, and the impact of implementing the plan. It is also intended to satisfy, in a single document, the requirements for the "preliminary plan" and the "plan of operations" in support of a geothermal mining lease and a conservation district use application (CDUA) as described in the following governing regulations:

- (1) Rules on Leasing and Drilling of Geothermal Resources, HRS", Title 13, Subtitle 7, Water and Land Development; Chapter 183, referred to hereinafter as "Title 13, Chapter 183."

(2) Rules on "Conservation District Use, Title 13, Subtitle 1 Administration, Chapter 2 "referred to hereinafter as "Title 13, Chapter 2."

General data required to support applications for drilling permits (Rule 183-65, Title 13, Chapter 183, HRS) is also included; it will be extracted and combined with more specific data as may be required at the time drilling permit applications are submitted. For example, the engineering details regarding construction and grading for roads, drilling sites and power plant sites will be included in the required permit applications for such operations.

Appendix A contains extracts of applicable regulations of the Department of Land and Natural Resources which provide the context in which this plan was prepared.

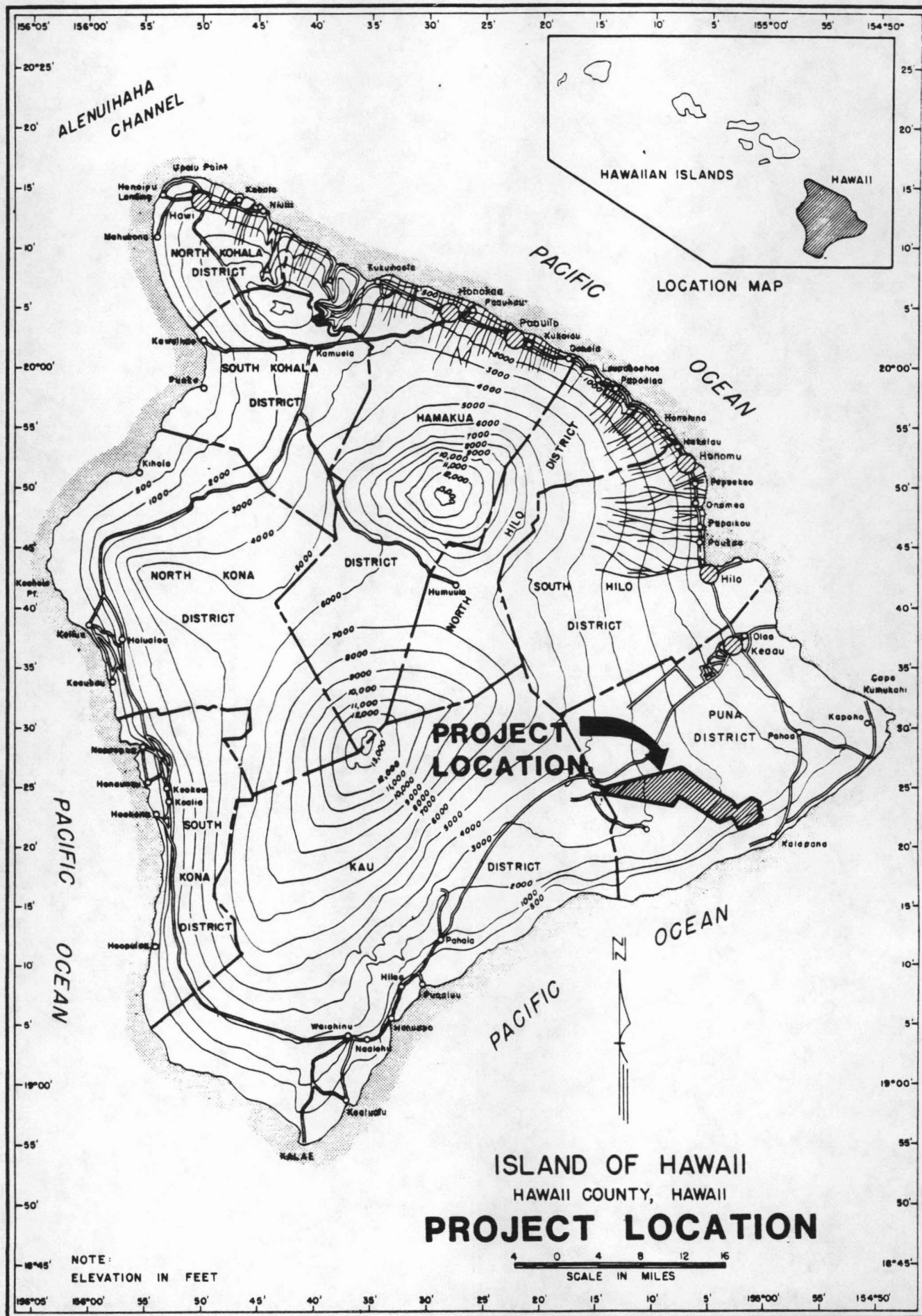
Appendix B contains a check list of the various actions required by Title 13, Chapter 183, HRS of the operator in conducting geothermal mining operations.

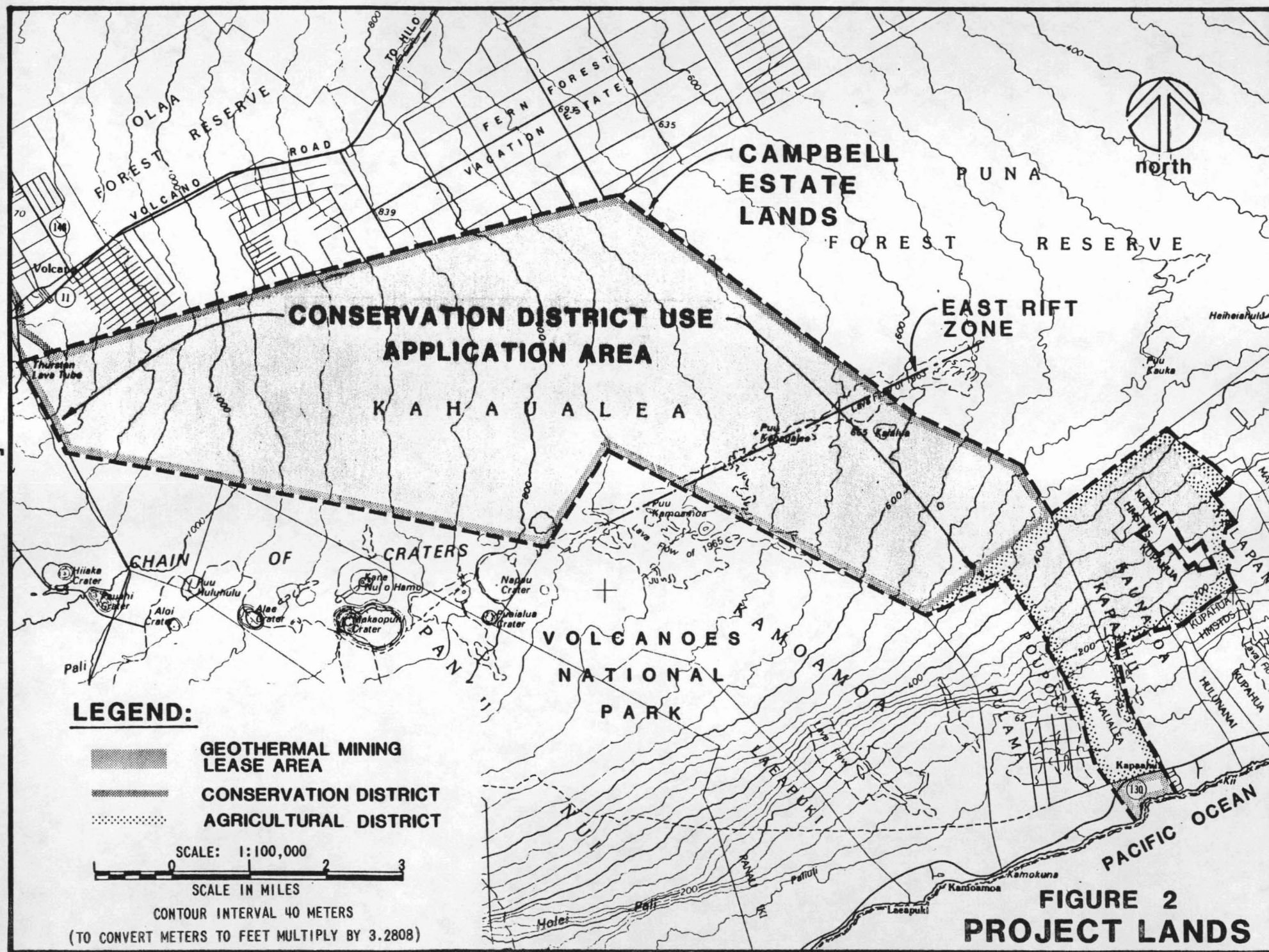
Upon approval of this plan by the Board of Land and Natural Resources, all changes including those subsequently directed by the Board and those changes within the purview of the operator as may be authorized by regulatory agencies will be promptly reflected in revisions and reported to all agencies monitoring the implementation of the plan.

LOCATION AND DESCRIPTION OF PROPERTY

The property on which a Conservation District Use Application (CDUA) and a geothermal mining lease are requested for exploration, development and marketing of geothermal resources is the Kahauale'a parcel in the Puna District, Island of Hawaii. Figures 1 and 2 show the location and project area maps. The property is shown on tax maps as T.M.K. NO. 1-1-01 Parcel 1, containing 21,943 acres more or less (Conservation District Sub-zone code L), and 992 acres more or less (Agricultural District) for a total of 22,935 acres more or less and adjoining parcel T.M.K. No. 1-1-08 Parcel 1, (Agricultural District) containing 2,526 acres for a total project area of 25,461 acres more or less. However, as indicated in Figure 2, the lower portion of T.M.K. No. 1-1-01 Parcel 1 will not be explored. Both parcels are referred to hereinafter as Kahauale'a.

The property is mostly forested except for areas of past lava flows. Canopy cover varies from open to 100%. It is relatively isolated, particularly in the area where most of the development activity is planned. The nearest known residence to the first drilling site is in the Fern Forest sub-division approximately three





miles distance. The nearest known residence to any of the planned drilling sites is in the Shipman Estate parcel (TMK 1-1-04, parcel 1) a distance of one mile. There are no known ground water resources within the boundaries of this property. There are no known recorded archaeological sites within the boundaries of this property. Field investigations will be made in any areas subsequently discovered to have archaeological value.

A base line environmental study of Kahauale'a has been accomplished with particular attention to access corridors and roads, initial drill sites, and power plant sites.

An Environmental Impact Assessment of the effects of geothermal development within this property, to include marketing of discovered resources through conversion to electrical energy, has been completed in support of the CDUA.

2.1 Adjacent and Surrounding Property

As shown on Figure 2, the property is surrounded by: the Puna Forest Reserve to the east; private property to the north, including Fern Forest Vacation Estates, two parcels (not sub-divided) owned by Shipment Estate,

the Royal Hawaiian Estates subdivision, and the Ohia Estates subdivision; the Volcanoes National Park on the west and southwest; and, a sparsely populated subdivision, Royal Gardens, on the south. There are also a number of residences south and southeast of Kahaule'a.

3.0 ACCESS TO PROPERTY

Access to Kahaule'a from the north leading from the Belt Highway (Volcano Road) will be gained through a 60 ft. easement granted to Campbell Estate by the Shipman Estate, TMK No. 1-1-04, parcel 10, across lots 55-A and 56. This easement, No. 215, on Map 23, was recorded at the Bureau of Conveyances in Liber 34-20, Page 280 on December 8th, 1981. A copy of this document is included as Annex D.

Access from the south can be gained directly off of Highway 130 (Kalapana Road) onto the Kahaule'a parcel. Due to the distance and rapid rise in elevation towards the first planned drilling site, this access is not presently considered desirable.

The preferred access would be via Captains Drive, Fern Forest sub-division, as it would afford the most direct

and shortest route to the first planned drilling site. However, the base line environmental study detected several endangered and rare plants along the direct route. While the site of these plants could be avoided by redirecting certain segments of the road, it was determined that pending further survey of that general area, an alternate access route should be selected even though it resulted in more than doubling the amount of road construction to the first drilling site. No further consideration will be given to the Captains Drive route at this time.

The second preferred access route is the uppermost road in Fern Forest subdivision commonly referred to as "B" Road or the "Secondary Entrance". Preliminary evaluations indicate there would be minimal environmental impacts from constructing a road to the first drilling site via this access road. The Board of Directors, Fern Forest Sub-Division has proposed that the developers use these above described roads to gain access to Kahauale'a and have initiated action to obtain approval from the association members and land owners. Thus, the uppermost Fern Forest road is shown as a potential future access road.

If the development plan is fully implemented, the road construction internal to the property will consist of

extensions of access roads to connect an east-west oriented road generally paralleling the rift zone with connecting roads to drilling and power plant sites. Additional growth of the rare fern, (Adenophorus Periens) previously seen in the Northeast section of the property, was cited in an area along the planned east-west access road. Special precautions will be taken to minimize the impact of road and site clearing in this area.

4.0 LAND OWNERSHIP, LEASING AND DESIGNATION OF DEVELOPER/
OPERATOR

The property is owned in fee by the Estate of James Campbell. The State of Hawaii claims ownership of all minerals underlying this property. "Minerals" has been defined by the State Legislature to include geothermal resources. The Campbell Estate will apply for a State Geothermal Mining Lease (and Conservation District Use Change) without waiving its claim to the mineral rights underlying the property. Upon obtaining such mining lease, and upon approval of the Board of Land and Natural Resources, the Campbell Estate will sub-lease the above-described property to True/Mid-Pacific Geothermal Venture (Developers) for exploration, development and marketing of geothermal resources. Terms and conditions of the sub-lease will include the terms

and conditions of the State Mining Lease. True Geothermal Energy Co. will become the "Operator" as defined in Chapter 183-3, HRS.

The following listed applications and permits are being prepared for submission and are based on this development plan:

- (1) Mining Lease Application (DLNR)
- (2) Conservation District Use Application (DLNR)
- (3) Drilling Permits for multiple exploration drilling sites and up to six development wells at each site. (DLNR; LUC and Hawaii County for mining lease area in agricultural zone.)
- (4) Water Drilling License (Chapter 444, HRS) (DWR)
- (5) Well Drilling Contractor's License (C-57) (DWR)
- (6) Grading and Construction Permits for initial development activity (DLNR & Hawaii county)

5.0 QUALIFICATIONS OF OPERATOR (TRUE GEOTHERMAL ENERGY COMPANY)

5.1 Managerial Capability

The True Companies have extensive experience in planning, control, directing and administration inci-

dent to their involvement in exploration for and development and marketing of energy resources. In addition to performance by in-house staff and supervisors, consultants and special technology firms are retained as required to provide the comprehensive management skills related to their field.

5.2 Technical Capabilities

The True Companies represent a highly qualified and successful oil and gas drilling, production and transmission organization with the capability to commence drilling operations in Hawaii immediately upon securing proper leases and drilling permits.

The True Companies are family owned and operated companies with a complete in-house staff of qualified and experienced personnel for conducting the exploration, development and transmission of energy resources. This includes the management and operation of support facilities, drilling rigs, transport vehicles, oil and gas pipelines and natural gas processing plants. The True Companies are also one of the major oil purchasing and marketing organizations in the Rocky Mountain area.

The operator has extensive experience in exploration and drilling for oil and gas in widely varying geologic

formations on the mainland. This experience readily relates and transfers to the drilling for geothermal resources since the specialized field of drilling engineering to support the geothermal industry has evolved from the basics of oil field drilling technology.

Because of the unique features of the Hawaiian geothermal reservoirs, various consultants are being retained. These consultants bring with them actual experience with geothermal exploration in Hawaii. They will provide support and assistance to the operator's inherent capabilities.

True Geothermal Energy Company has committed to bring to Hawaii a National 50A drilling rig, or one of comparable capacity, with more than 750,000 pounds of lifting capacity and capable of drilling to depths of 13,000 feet. This equipment will allow the operator to: reach the deeper depths required for optimum evaluation of geothermal reservoirs, more efficiently and rapidly; drill sufficiently large diameter holes thereby enabling maximum volume and flow rates from the reservoirs; reach effective exploration depths thereby reducing the possibilities of the premature abandoning of prospect areas, due to a lack of sufficient penetration.

5.3 Operation of Power Plant

The principals in the True/Mid-Pacific Geothermal Venture are primarily involved in operations to explore for, develop, distribute and market energy resources, but also have the capability and incentive to promote the planning and operation of power plants as necessary. This would involve the use of staff expertise in addition to the use of recognized and experienced consultants and construction firms.

6.0 ASSESSMENT OF GEOTHERMAL RESOURCES POTENTIAL FOR KAHUAUAE'A

6.1 General

An assessment of the geothermal resource potential of the Hawaiian Islands was made using available geological and geophysical data of which the primary sources were the geological maps and published reports by eminent geologists such as Dr. Harold Stearns and the late Professor Gordon Macdonald. We have combined with these data the published data from the geothermal research group at the Hawaii Institute of Geophysics of

the University of Hawaii and have used this combined data set and aerial photographs to determine the areas thought to have geothermal potential in the State of Hawaii, with special emphasis on the Big Island.

6.2 Rift Systems

Kilauea volcano has two rift zones running generally east and west through which magma (molten rock) moves in the subsurface whenever volcanic eruptions take place in the lower elevations of the rift zone.

The east rift system of Kilauea volcano passes through, (or is adjacent to) significant portions of the Kahauale'a property in the vicinity of Puu Kahauale'a. It is our belief that sufficient heat has been retained in the sub-surface to make possible a viable geothermal resource. The currently active east rift system (last eruption in this area in 1977) has a trend of approximately North 65° East in this area. The region of historical activity has a width of about 1 mile and a length of about 3 miles beneath this portion of the property. To the west of Puu Kahauale'a the most active portion of the rift system lies within the Volcanoes National Park, but a portion of this active zone also lies within the Kahaualea property north of

Napau Crater. The area of this portion of the active rift zone within the Kahaualea property is about 1-1/2 square miles.

To the north of the currently active rift is a zone about 1-1/2 miles wide that appears to be a rift system that is about 300 to 500 years old (total area of about 10 sq. miles) and appears to have considerable geothermal potential with extremely low volcanic hazard. Several craters and areas of irregular topography lie to the south of the active rift zone and suggest that this area may also be underlain by geothermal resources.

6.3 Historic Lava Flows/Heat Concentrations

Within the most active portion of the rift zone there is extensive evidence of igneous activity, for flows have erupted from fractures and vent lines parallel to the rift in 1840, 1922, 1963, 1965 (extensive), 1968 and 1977. Since all of the material that feeds the lower portion of the rift system must also pass through this area, one knows that heating at depth has also occurred in 1755₊, 1790, 1840, 1924, 1955, and 1960, for these are the times of known eruptions or intrusive events in the rift zone east of Kahauale'a. Moreover,

a considerable body of evidence exists that suggest that large volumes of molten material are stored in the rift zone at all times (Macdonald & Eaton, 1964).

Thus, from geologic considerations alone, it is likely that the subsurface is at elevated temperatures throughout the rift zone and that the amount of elevation of temperature should increase as one approaches the Kilauea crater. Although the distribution of heat and the detailed geology within a rift zone is not well known at this time, one can infer that the general structure might be both parallel to and perpendicular to the rift zone.

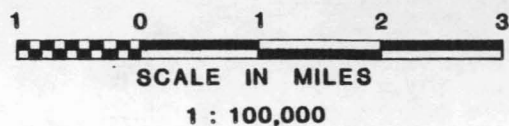
6.4 Nature of Geothermal Fluids

The nature of fluids within the geothermal system beneath Kahaualea area are not known at this time but they will probably be similar to those found at the HGP-A site. The lavas that comprise most of the above sea level portion of the rift are very porous and thus it is unlikely that a high level dike-impounded water system will be found. However, the occurrence of bogs at the surface in this high rainfall region suggests that this may be possible.

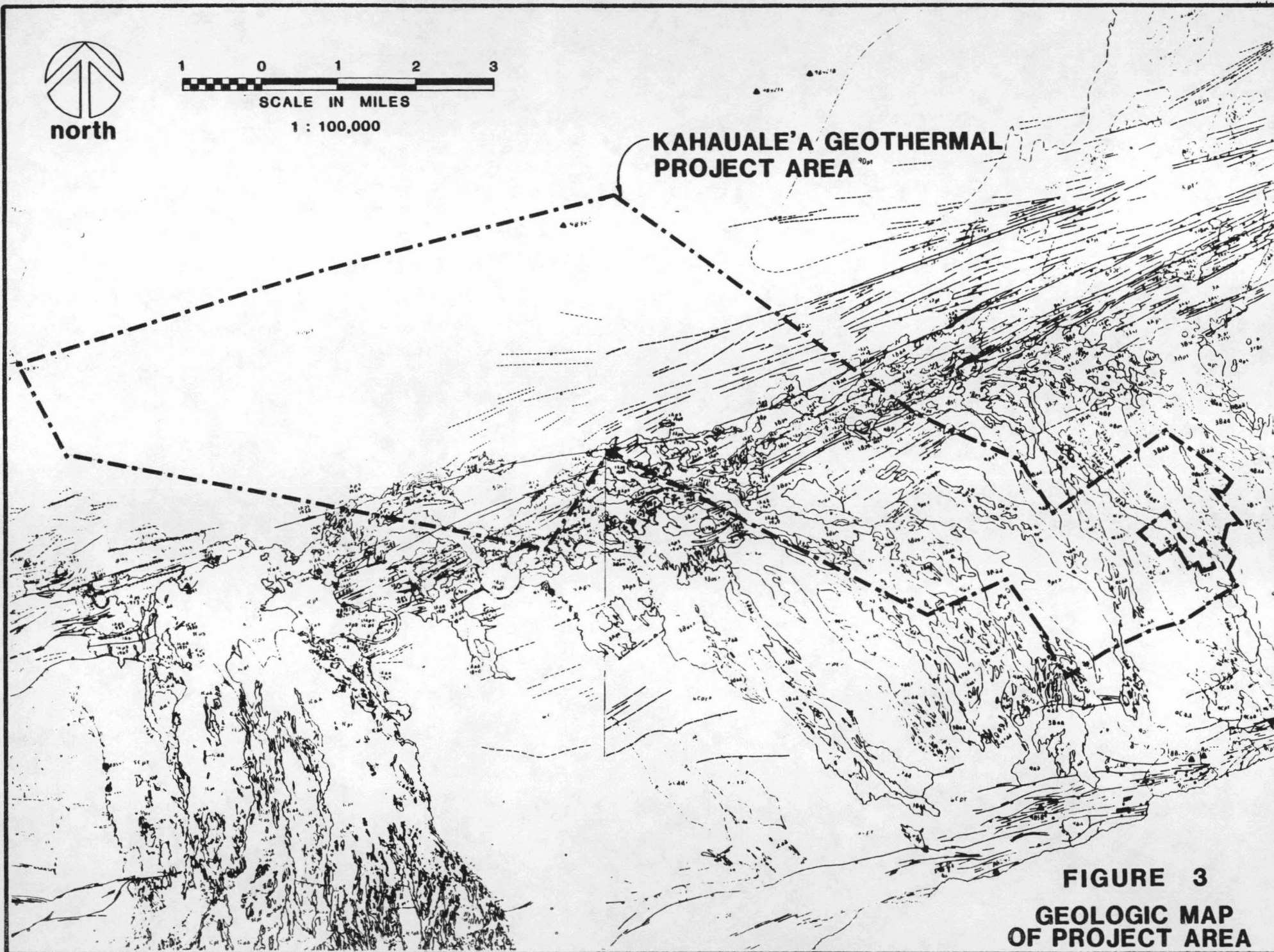
6.5 Geology of Kahauale'a

A recent study of the Kilauea volcano by Robert Holcomb, PH.D. Dissertation at Stanford University, provides considerable geologic detail for the area as shown in Figure 3, modified from his Plates I and II. The trace of the southeast rift zone can clearly be seen as a series of more or less parallel faults and fissures crossing the central portion of Kahauale'a and having a trend of N65E to N80E. The rift zone is about 2.5 to 3 miles wide at this point although its northern and southern boundaries are difficult to delineate precisely. The southern boundary tends to be obscured by the many lava flows that "cascade" down it, some of which almost reached the coast as did the 1977 Kalapana flow. Within the rift zone itself there are numerous small ponded flows most of which have surface areas 0.2 square miles or less. Due to the slope of the land almost all major flows curve to the south (down slope) not far from their point of origin.

To the north of the rift zone itself a series of indistinct linear trends are present (shown as dashed lines in Figure 3). These features probably represent the fissures and faults of an older rift zone but dense forest cover obscures much of its detailed expression.



**KAHAUALE'A GEOTHERMAL
PROJECT AREA**



**FIGURE 3
GEOLOGIC MAP
OF PROJECT AREA**

To the north and west of this indistinct older rift zone is a relatively monotonous slope covered by pahoehoe lavas derived from a volcanic center located in the vicinity of Thurston Lava Tube. These lavas, 350 to 500 years old, appear to bury any evidence of the western portion of this older rift system throughout much of the western portion of Kahauale'a.

A volcanic center, named "Hale O Ai-Laau" by Holcomb, appears to have been active 350 to 500 years ago in the western most portions of Kahauale'a. Hawaiian legend refers to this volcanic activity and one can infer that this is the volcanic center that was responsible for the extensive volcanic shield that emanates eastward from the Thurston Lava Tube to beyond the eastern end of Fern Forest Estates. This was apparently a long-lasting volcanic center of the Mauna Ulu type and thus should be considered to be a potential geothermal prospect.

6.6 Potential Energy Production

Based on our calculations on the amount of magma stored in the rift zone, it is estimated that upwards of 200+ MWe could be produced from the active areas of the rift zone passing through the Kahauale'a property and from

areas within the property which are adjacent to the rift zone. In addition to this reservoir potential, the older rift zone north of the active rift zone may contain heat, but no estimates can currently be made for resources in this area of the Kahauale'a property.

7.0 CONCEPT OF DEVELOPMENT

7.1 General

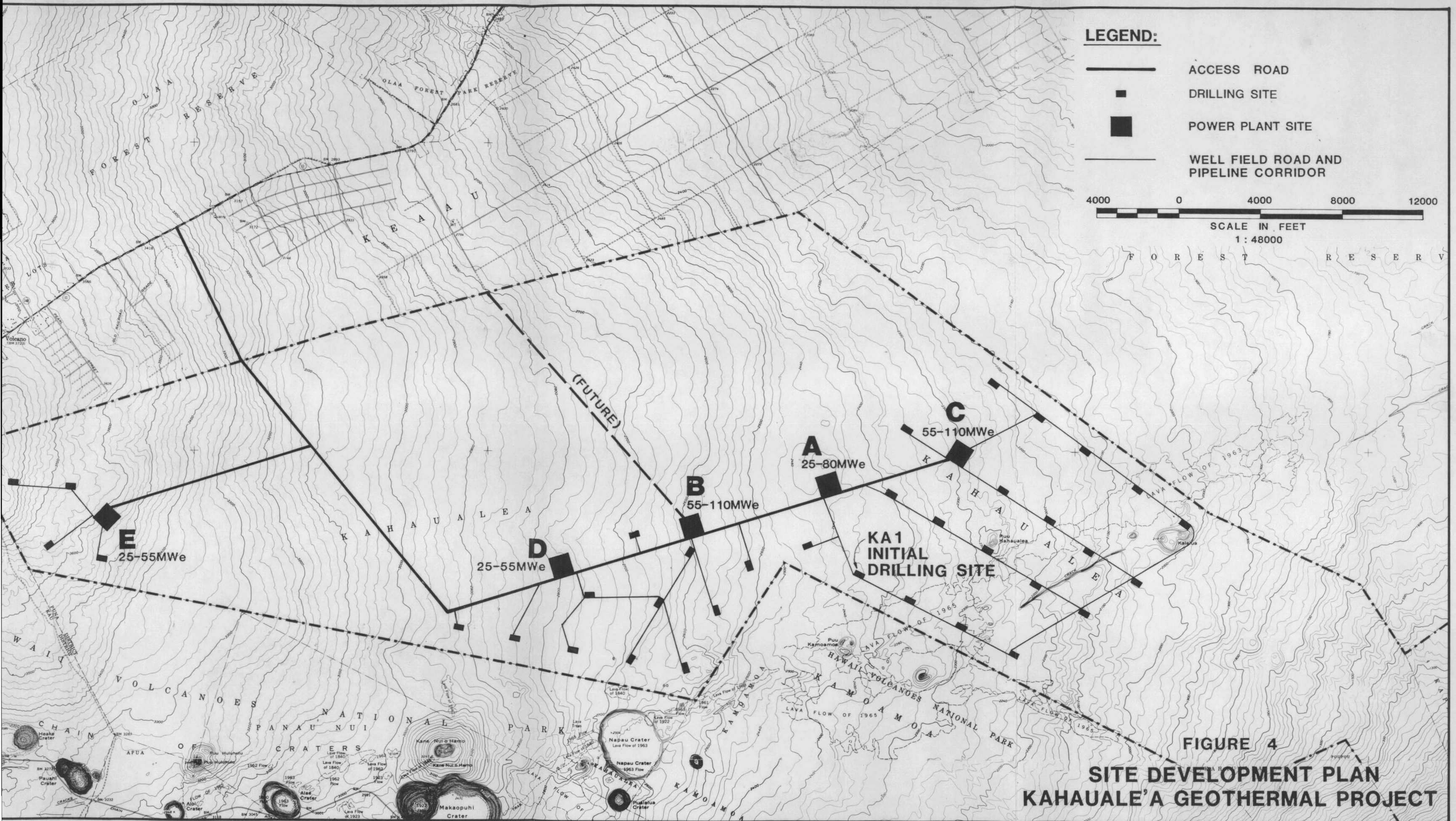
The existence of geothermal resources can only be determined by drilling of exploration wells to the depths of existing reservoirs, which in Hawaii is expected to occur between 4,000 ft. and 8,000 ft. below sea level. Our concept of development is designed to allow for concurrent exploration and development effort as provided for in Chapter 183-19, HRS. A successful exploration effort would be followed immediately with development (production) drilling, followed by construction of facilities (power plants) to convert geothermal energy into electrical power, to meet the then current level of demand or market for such energy. It is planned that all wells will be designed and drilled as development (production) wells, (i.e., conventional hole

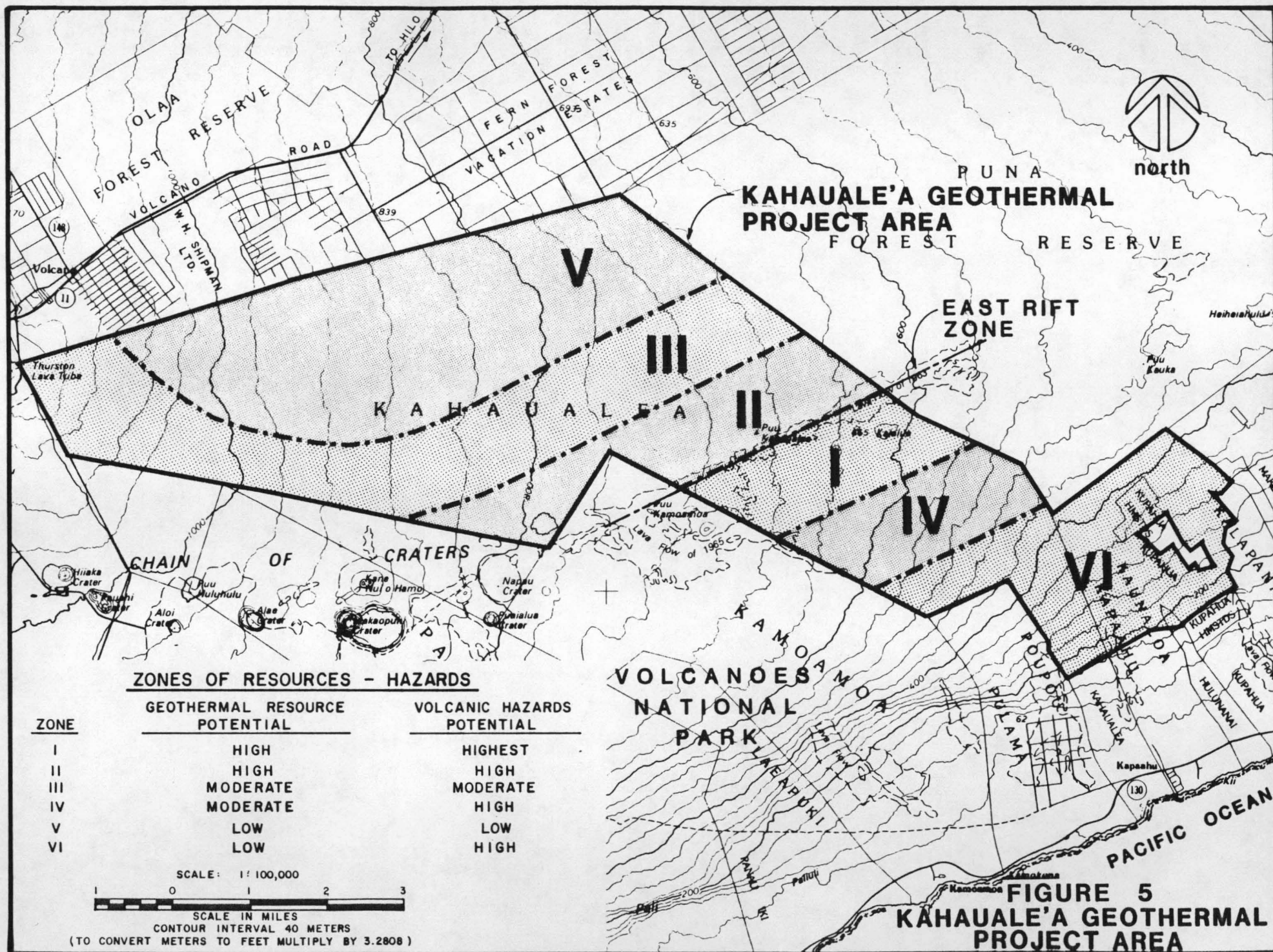
completion) even though the purpose of the drilling may be for exploration to discover a resource. Full implementation of the plan will require between 14 to 20 years (beginning in 1982), depending primarily on the extent of the resources underlying the property and the rate at which a market to use the discovered resources is developed. Figure 4 shows the site development plan for the project on a U.S.G.S. topographic map, scale 1:48,000. (Appendix C represents the site development plan on a U.S.G.S topographic map, scale 1:24,000).

7.2 Development Strategy

The geophysical assessment of the property together with historical data of volcanic eruptions from Kilauea and along the east rift zone, and the data obtained from the HGPA, allow us to project that sufficient geothermal resources are available within the boundary of the property to produce up to 250 MWe and to provide some resources for direct use applications in the future.

The most likely prospect areas within the property have been identified based on proximity to the east rift zone and to the Kilauea Iki Crater. Figure 5 shows the potential resource zones in relation to potential volcanic hazards zones. Within the several prospect areas, planned drilling sites and power plant sites





have been tentatively located. It was determined that 35 multiple-well drilling sites would be required to fully develop the geothermal resource potential of the property. The location of these sites and the sequence of drilling are intended to balance the prospects of discovery in potential resource areas with acceptable risks from volcanic hazards. Selection of additional drilling sites as may be required to achieve the development objectives of this project will be based on the results of all previous drilling on the property.

Five electrical power plant sites are located within one to two miles of the drilling sites, except in several cases where volcanic hazards potential dictates further separation between wells and power plants. The final location of a power plant, and its generating capacity, will be determined primarily by the location and characteristics of producible wells, volcanic hazards, and environmental considerations.

Initial project activity through 1987 will be directed towards discovery and development of resources to compete for a contract with Hawaiian Electric Light Company (HELCO) for supplying base load power up to 25MW. If successful, a power plant with the required capacity will be constructed. Additional exploration

drilling as may be feasible will be conducted during this period to extend the known area of proven reserves. Additional development drilling would be undertaken to meet new or potential market demands. The impetus towards proceeding with plans to interconnect the islands with an undersea transmission cable depends largely on demonstrating the existence of sufficient, reliable resources in the Kilauea rift zone to supply the cable. It would require 20 successful exploration wells to prove the potential of the Kahauale'a parcel to produce 250 MWe (Figure 6 shows the preliminary schedule for the project exploration and development activity. Figure 7 provides a recapitulation of the projected distribution of power production capacity by year at the plant sites).

Up to 42 exploration and development wells could be drilled during this period if warranted by drilling results and market demand. It would be possible to continue at this rate so that by 1994, there could be a sufficient number of production wells to produce approximately 150MW of power, and 250MW by the year 2002.

After 2002, project activity would consist primarily of drilling replacement wells and well field maintenance operations to maintain production capability, and of additional exploration drilling.

KAHAUALE'A GEOTHERMAL PROJECT SCHEDULE

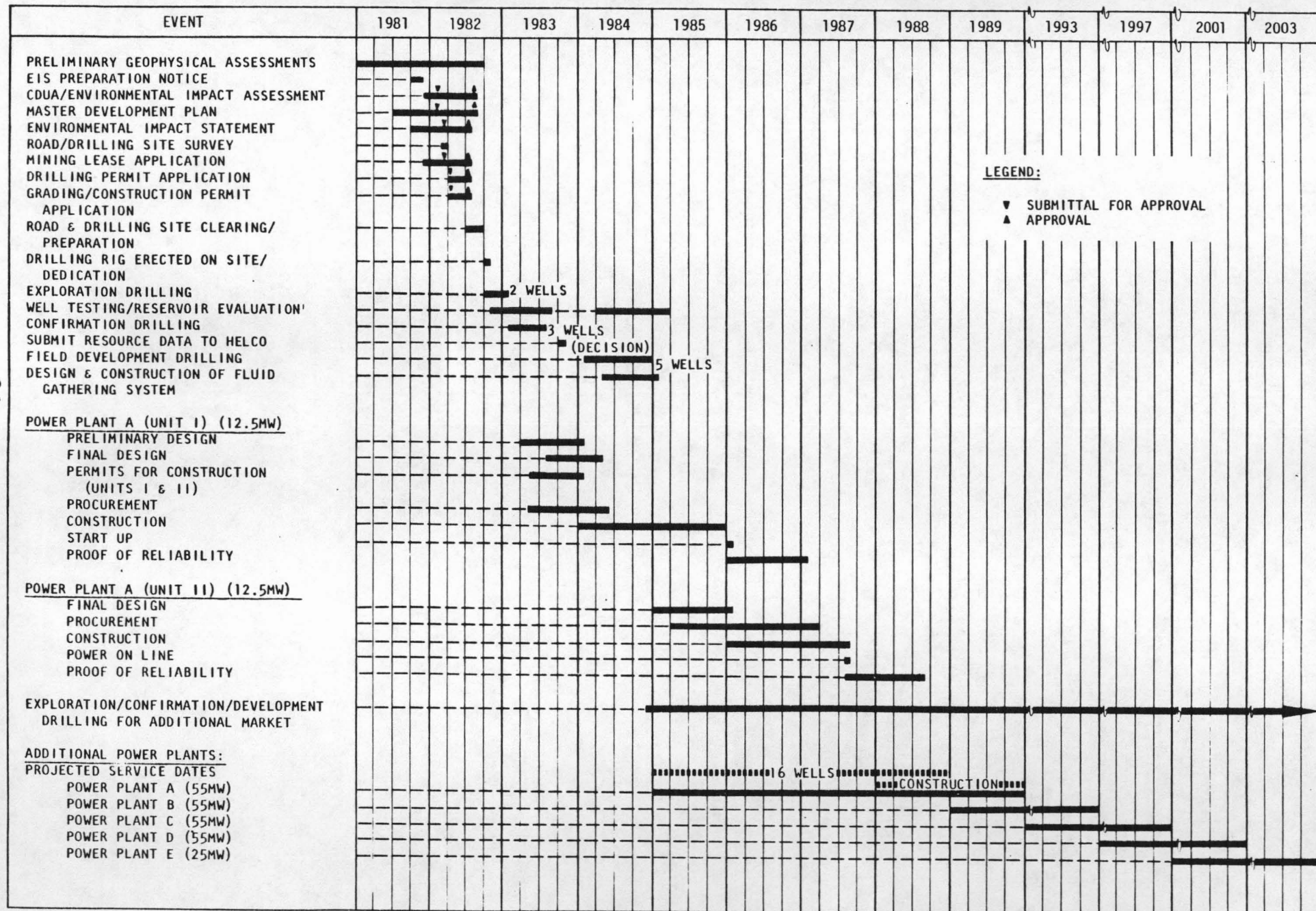


FIGURE 6

1/29/82

PROJECTED DISTRIBUTION OF
POWER PRODUCTION CAPACITY

<u>Plant Site</u>	<u>Potential Production Capacity</u>	<u>Cumulative Total</u>	<u>End Year</u>
	Begin Operations. <u>1982</u>		
A	25 MW	25 MW	1985
A	55 MW	80 MW	1989
B	55 MW	135 MW	1993
C	55 MW	190 MW	1997
D	55 MW	245 MW	2001
E	25 MW	270 MW*	2003

* If the resource supports this scenario, an amendment to the the Master Plan and EIS would be required when production capacity reached 250MW.

Figure 7

7.2.1 Probabilities of Discovering Producing Geothermal Resources

It can be projected that the probability of discovering a geothermal resource in the project area is high; however, the probability of discovering a producing resource at any particular drilling site is less than 50%. After a discovery is made within a drilling site, we expect that one of three wells will be unsuccessful, that is, have inadequate production to be economically viable. Hence, the number of planned drilling sites is more than we can anticipate developing.

Using geological data gained from previous drilling to influence the choice of subsequent drilling sites, the number of unsuccessful wells drilled can be minimized, in turn reducing the total number of wells drilled to fully develop the resource potential of the property.

7.2.2 Drilling in Relation to Resource Potential and Volcanic Hazard.

In order to enhance the chances of discovering a producing resource on the first well, the first drilling site "KA1" as indicated in Figure 4, will be in an area of high potential recognizing the possibility of hazard due to lava flow. In attempting to define the boundaries of the producing reservoirs, subsequent exploration

drilling, assuming success on the first well, will move towards areas of gradually reduced potential and volcanic hazard. As reflected in Figure 5, our evaluations indicate the resource potential diminishes rapidly as the distance from the rift zone increases. However, the potential is considered to increase again in the Northwest area of the property due to its proximity to Kilauea Iki Crater. The lava flow hazard is greatest in the active area of the rift zone and south of this zone and reduces towards the north and west.

7.2.3 Influence Of Drilling Results On Development Plan

After an initial discovery is made, the characteristics of the resource and reservoir must be evaluated through analysis of the fluid and flow testing of the well while simultaneously initiating the drilling of one or more confirmation wells to ascertain the dimensions of the reservoir and to obtain additional data on the production characteristics of the resource/reservoir. Data thus derived will be used to justify undertaking of development (production) drilling to supply a market.

After reservoir confirmation and evaluation is completed and a decision is made to develop and market the resource, development drilling will be initiated in

one of the exploration or confirmation drilling sites from which a discovery was made or confirmed. If directional drilling is not feasible from any successful exploration or confirmation drilling site, it will be necessary to drill from single well sites initially spaced to optimize production and utilization of the resource. In such cases it is anticipated that up to 6 step-out wells would be drilled within a radius of 2000 ft. from the intended multiple drilling site.

Concurrently with commencement of development drilling, refinement of the development plan for the area of discovery can begin. For example: planned development drilling patterns may be adjusted if required, to move in the direction of the indicated reservoir trend; production and marketing plans can be adjusted; preliminary designs for the type of power plant most suited for a particular reservoir can begin; earlier assumptions can be validated or invalidated; and adjustments as required can be made in the development plan.

7.4

Discovery, Production, and Reinjection Zones

It is estimated that resources underlying the Kahauale'a property will be discovered at depths beginning at 4,000 ft. below sea level; that the optimum

production zones of a reservoir will range at depths between 6,000 and 8,000 ft. below sea level; that the re-injection depth can be set at approximately 1,000 ft. below sea level depending on the local geology. Abandoned wells will be plugged in accordance with Chapter 183, Subchapter 19, HRS, and State mining lease requirements, but, normally, at three locations: at the surface; near sea level; and at least one point substantially below sea level near the base of the fresh water lens.

4
7.5

Scope of Planned Development Activity

In spite of a number of uncertainties about locating and producing geothermal resources, the developer recognizes the need to be as definitive as possible in preparing the Master Plan for development so that all review and approval agencies and the public will know what is being requested for approval and how it will be implemented if approved. Therefore, we have limited the scope of our plan in the following areas to better define the major parameters on which regulatory agency review and permitting decisions can be made:

- (1) The development plan is designed primarily to convert discovered geothermal resources into

electrical energy with steam turbine generator power plants for sale to public utilities or directly to an industrial user of electric power. Other uses of geothermal resources for direct use applications can be expected to develop at which time amendments to the Master Plan and EIS would be submitted for approval.

- (2) The potential amount of electrical production projected to be generated from this property is forecast at 250 MWe. Power plant capacity will be limited at one site to 110 MWe. If an increase in production in excess of 250 MWe can be achieved and the market to use this additional power develops, an amendment to the Master Plan and the EIS would be submitted for approval.
- (3) In achieving the electric energy production objective of this plan, the total land areas to be disturbed from our exploration and development activities and the construction of gathering systems and electrical generating facilities, is not expected to exceed 900 acres of the 25,461 acres of the property. Depending on the exit location selected by HECO, the right of way for power transmission lines could require up to 100 acres. If directional

drilling is not feasible, an additional 220 acres (approximate) would be used for individual production wells.

8.0 TECHNICAL AND ECONOMICAL CONSIDERATIONS

The principal technical and economic considerations which affect the implementation of this plan are as follows:

- (1) Selecting potential drilling sites which offer the best potential for locating a producible resource while simultaneously minimizing the potential for volcanic and seismic hazards.
- (2) Selecting the sites for power plants or other consumer facilities in not only safe areas, but in close proximity to the producing wells to allow economic transport of the geothermal fluids to the using facility.
- (3) Providing for the proper spacing of production wells to attain optimum use and conservation of the discovered geothermal resources.

- (4) Evaluating of any discovered resources and reservoir(s) to determine whether long term, quantity production is technically and economically feasible and making the decision to proceed with development.
- (5) Optimizing the rate of exploration and development efforts to either satisfy an existing market or promote a potential market.

8.1 Project Cost Estimates

While little industry experience data on geothermal exploration and development costs has been developed in Hawaii, experience data from other development areas can be used as a guide to develop initial cost estimates for the early phases of the project. Because of the widely varying conditions in each development area, especially as to the nature and quality of the discovered resource and the underlying geologic structure, a range of costs for the various operations and components of the project has been used. The initial cost estimates are projected for a 25 MW resource production capacity and power plant. If the project is successful, and additional resources are discovered to meet a market demand, adjustments in these estimates

will be made as incremental development occurs. New technology and environmental considerations that may be reflected in subsequent development could cause significant differences in project costs.

The following cost estimates (1981 dollars) are projected for an initial 25 MW production and generating capability:

---Shipping Costs \$.3 to \$.5 million

---Total Average Cost

per 10,000 ft. well \$1.7 to \$2.5 million
(Includes all costs for labor, a pro-rated share of road construction, site preparation, drilling pipe, casing, cement, drilling supplies, equipment, maintenance and well logging.)

---Fluid Gathering System \$5.3 to \$7.3 million
(Includes well head equipment, pipelines and supports, separator-silencers, flash tanks and settling tanks.)

---Power Plant per MW \$1.0 to \$1.5 million
(Includes generator, steam turbine, condenser, pump systems, emission abatement systems and cooling towers.)

---Field Operations & Maintenance

per year \$.8 million
(Includes maintenance of well bore and well head equipment, reworking of wells. Does not include costs of drilling replacement wells.)

Excluding capital costs of drilling rig and equipment and post development operating costs, it is estimated that exploration and development costs to deliver 25 MW of electricity will range between \$44.0 and \$65.0 million.

CONTINGENCIES

Following is a list of events which should they occur will result in adjustments in the Master Plan.

- (1) Development schedules may be delayed due to lack of market, unexpected technical and mechanical difficulties in drilling, and natural causes; or, the development drilling may be accelerated in the event markets develop earlier than forecast.
- (2) The drilling sequence and pattern, road locations and power plant sites and size may have to be altered due to information obtained from previous drilling, geophysical data, reservoir analysis and environmental considerations.
- (3) Unexpected difficulties in directional drilling from a planned multiple (development) drilling site could require that some or all development wells be drilled vertically from separate surface sites.
- (4) Well testing/resource evaluation may have to be extended due to difficulties encountered during the regular test period.

- (5) Notwithstanding the relative isolation of this property, and the installed noise attenuation devices, noise levels from drilling, construction, and well testing due to climatic conditions may temporarily exceed standards at the nearest residence.

10.0 CLEARING AND GRADING OPERATIONS

10.1 Preliminary Planning

Clearing and grading operations for road construction, drilling sites, transmission pipelines routes, power plant sites and electrical transmission lines will be carefully planned and designed to minimize disturbance of the surface area. (See Appendix C for site locations.)

10.2 Access Road Development

Road and site engineering surveys will be initiated following completion of geophysical surveys which are being conducted to validate the location of the first planned drilling sites.

Approximately 9 miles of access road will be required to reach the first planned drilling site using the access through the Shipman Estate parcel (T.M.K. No. 1-1-04, parcel 10). The need for clearing and grading of additional roads will depend upon the results of initial exploration and development activities. However, total road construction within the property is not expected to exceed 130 acres out of a total land area of 25,461 acres if the resource capable of producing 250 MWe is located in the vicinity of the planned drilling sites. Initial road clearing to the first drilling site will be limited to a width of 16 - 20 feet. If the exploration and initial development effort is successful, roads will be widened to 30 feet between access points on the property boundary and the power plant sites and 40 feet clearance between power plants and well sites to accommodate the geothermal fluid transmission pipeline along the roads.

10.3 Preparation of Drilling Sites

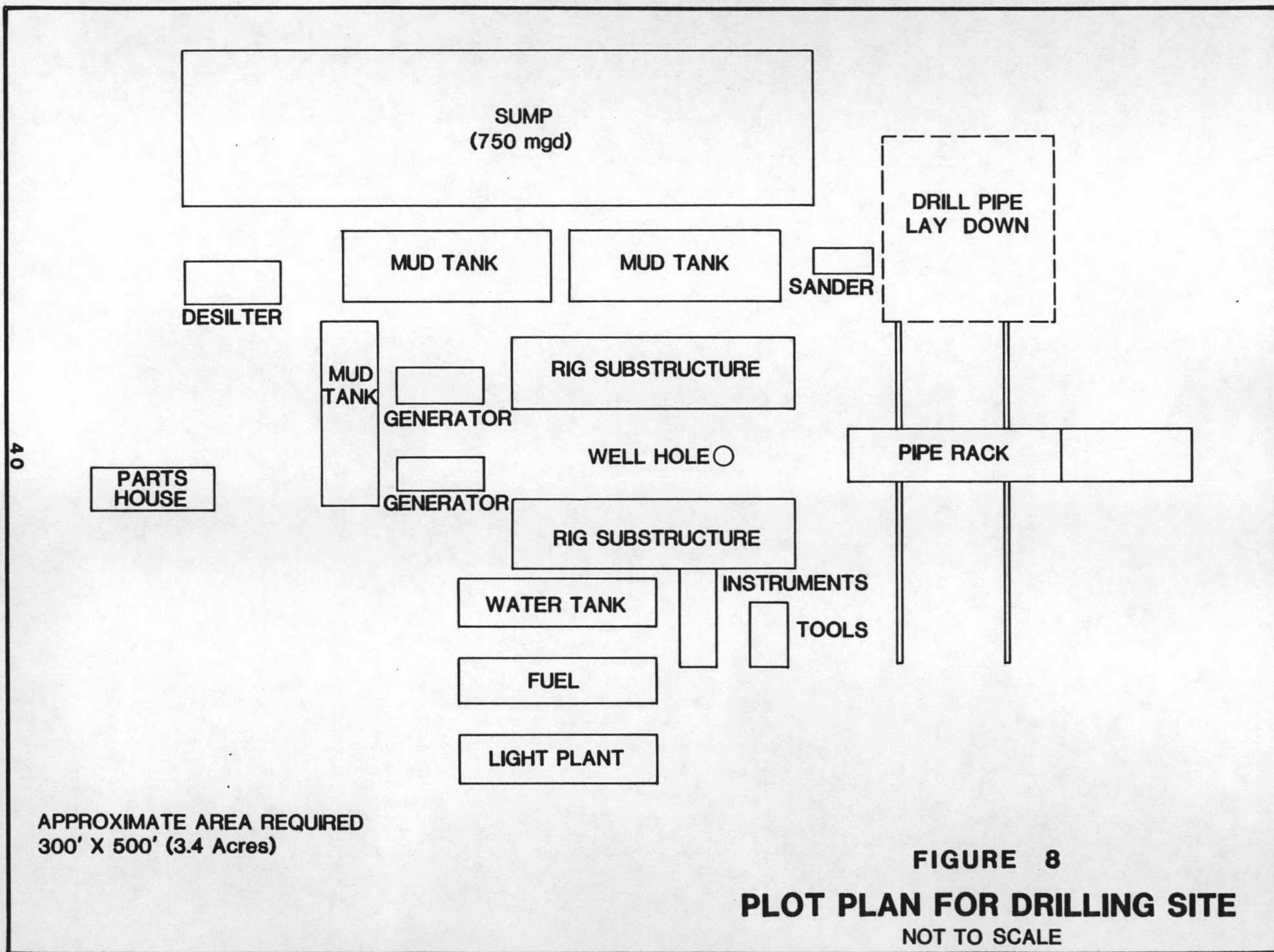
Each multiple well drilling site will require approximately 5 acres. However, the cleared area for each site may be limited initially to approximately 2 acres for drilling of the first well. If the exploration results in a discovery of a producible resource that

site will become a development site where multiple production wells can be drilled directionally from the same site. In such cases the drilling site would be expanded in size to a 5-acre plat. (A typical drilling site layout is shown in Figure 8).

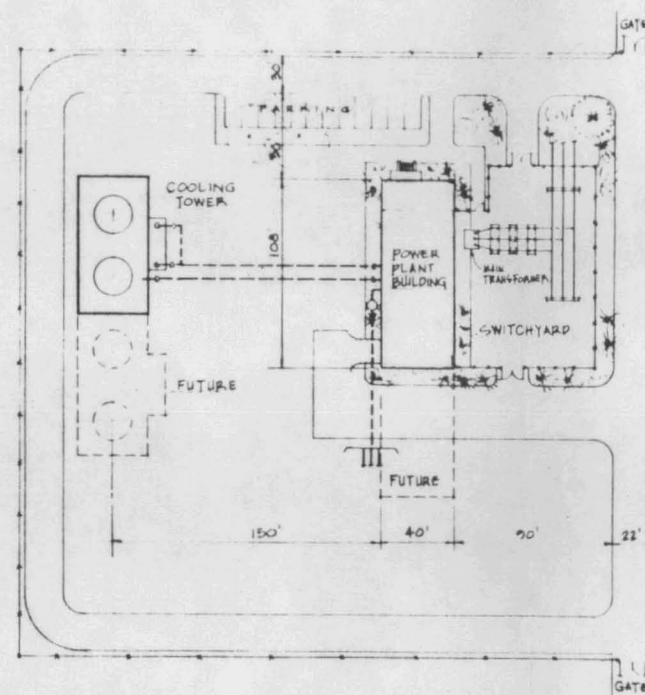
The planned configuration for a single well site is a rectangular shaped, cleared area approximately 300 ft. in length by 150 ft. wide to include a disposal sump with a depth of 10 - 12 ft. and a capacity of 750,000 gallons (100,000 ft. ³). A 60 ft. wide perimeter around the drill site will be established for safety and control. Over a period of 14-20 years, it is possible that a total of 17 exploration/development drilling sites covering approximately 5 acres each in size would be occupied, assuming the resource is spread throughout the property in the areas of greatest potential, and directional drilling is possible at each site.


10.4 Site Preparation for Power Plants

Power plant sites are located in close proximity (within 1 or 2 miles) to the expected resource discovery areas to minimize road construction, length of transmission pipelines and heat loss during transport of the fluid, and in recognition of volcanic hazards.



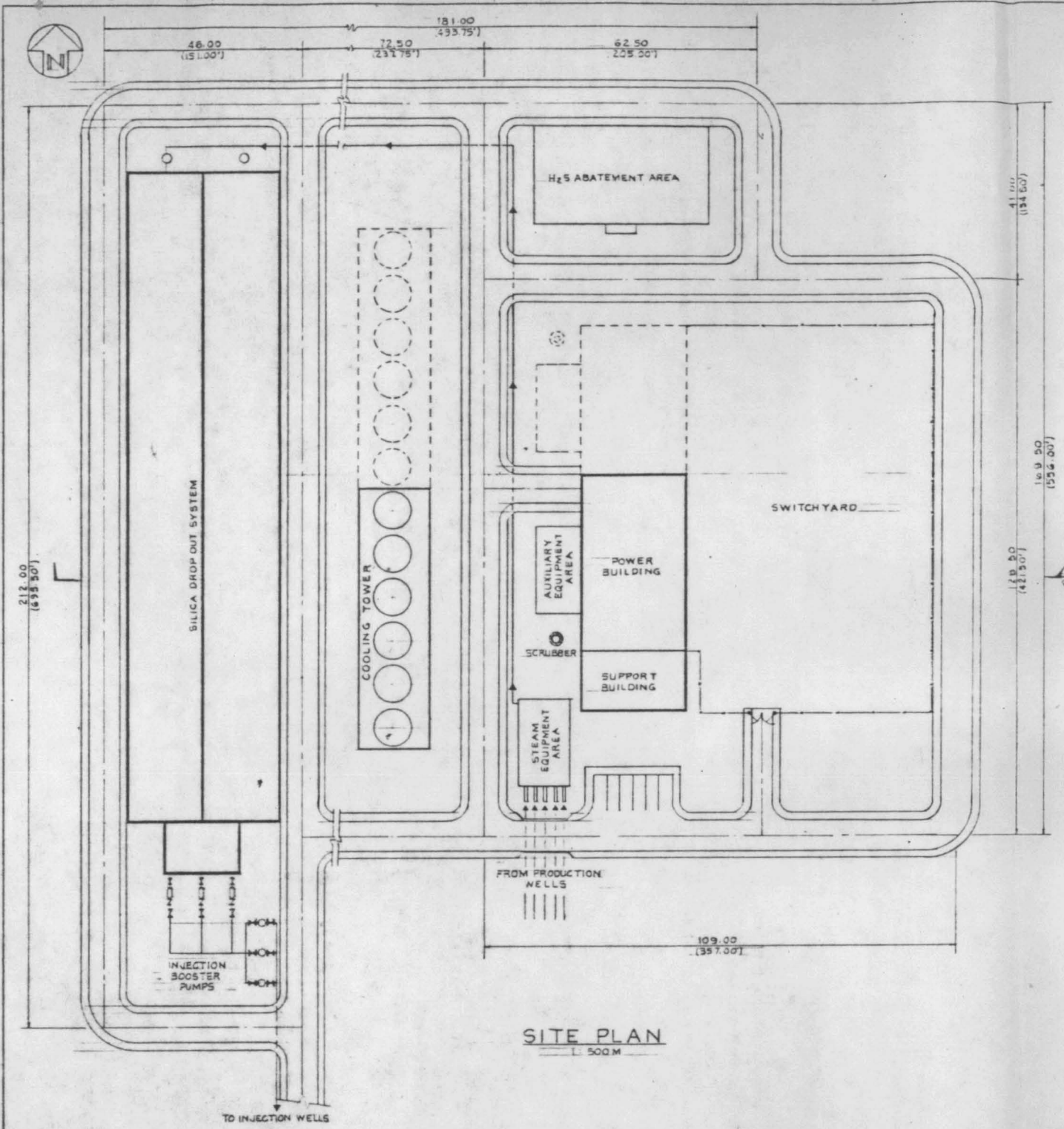
There are 5 power plant sites planned throughout the property. Each site will be a rectangular shaped, cleared area containing a power building, support building, switchyard, cooling towers, silica drop out pools and auxiliary equipment area. Depending on the terrain and capacity of the plant, each site will require 7 to 15 acres, not including perimeters for safety and control. Drawings E-04-002, and E-04-001-01 illustrate site plans for a 25 MW and 110 MW plant site.



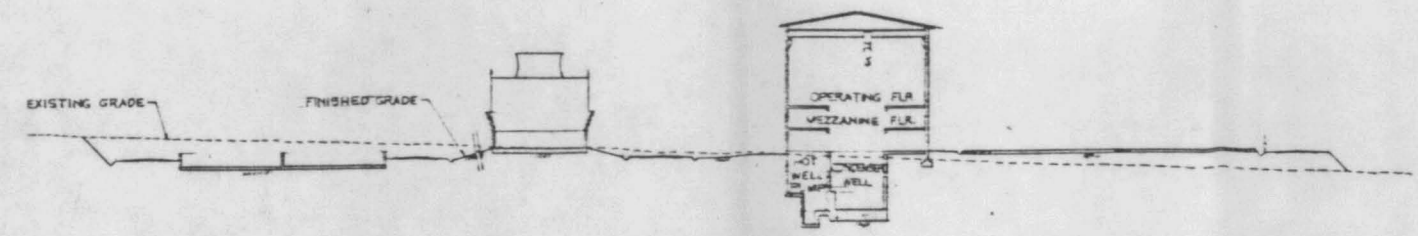
										 ROGERS ENGINEERING CO., INC. ENGINEERS - ARCHITECTS 111 PINE STREET, SAN FRANCISCO, CALIFORNIA 94111										TRUE/MID-PACIFIC VENTURE										PROPOSED 12.5 MW GEOTHERMAL POWER PLANT PUNA DISTRICT HAWAII SITE PLAN									
SCALE 1" = 20' NOTED										DATE 6-30-81										APPROVED _____ DATE _____																			
DR. G.O. _____										CHK. _____										ENL. _____										APPROVED _____									
REFERENCE DRAWINGS										REV. DATE REVISION										REV. DATE REVISION										REV. DATE REVISION									



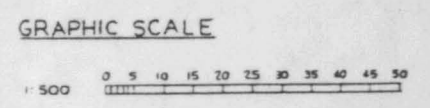
- NOTES:
- 1. BUILDING CAN BE EXPANDED TO THE NORTH IF AN ADDITIONAL 55 MW UNIT IS REQUIRED.
 - 2. COOLING TOWER CAN BE EXPANDED TO THE NORTH IF AN ADDITIONAL 55 MW UNIT IS REQUIRED.
 - 3. WIND DIRECTION AND VELOCITY DATA.



SITE PLAN
1" = 500'



SECTION A
1" = 500'



REFERENCE DRAWINGS					REVISION					REVISION					REVISION				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

ROGERS ENGINEERING CO., INC. ENGINEERS - ARCHITECTS 111 PINE STREET, SAN FRANCISCO, CALIFORNIA 94111		TRUE/MID-PACIFIC VENTURE		55 MW GEOTHERMAL POWER PLANT KAHAUALE'A CONCEPTUAL STUDY SITE PLAN	
SCALE AS SHOWN	DATE 12-29-81	APPROVALS		JOB NO.	REV.
DR. MCP	CHK.	DATE	DATE	581010	A
APPROVED				E-04-001-01	

11.0 DRILLING PLAN

11.1 General

Drilling operations are planned to commence within 4 months after the developer obtains the last required permit or license from the applicable Federal, State or County regulatory agency. Following a discovery, confirmation drilling and well testing will be conducted to determine the nature and extent of the reservoir, and if warranted by the results, development (production) drilling will be initiated to meet a market requirement. If no immediate market exists, additional exploration wells may be drilled in the project area to further define the extent of the reservoir(s) underlying this property and to enhance development of a market for these resources.

11.2 Location of Drilling Sites

For each reservoir, there is an optimum well location plan and well density that provides the maximum production rate under the prevailing operational and economic conditions. Pending resource discovery and completion of reservoir engineering analysis, the number and location of planned drilling sites were determined on the basis of geophysical and surface geologic data, and the

normal drilling pattern for initial spacing of 1 well (bottom hole) per 40 acres in those areas assumed to have high and moderate potential for geothermal resources. The pattern was adjusted wherever possible to minimize volcanic hazards and to minimize adverse environmental impacts.

11.3 Designation and Marking of Drilling Sites

Drilling sites are designated by a code which will inter-relate all drilling conducted within a development area to a specific power plant that is to be located in that area to receive production from the wells. The designation code consists of 2 letters and a number to identify the site, followed by a second number to identify the well within a specific site. For example: "KA1", where "K" represents the Kahauale'a Geothermal Project; "A" identifies the power plant; "1" signifies the first drilling site in the project area for power plant "A" site. Adding a second number, e.g. "KA1-1" indicates the first well drilled within the first drilling site.

11.3.1 Classification of Wells

All reports on wells will use the designation code followed by a letter in parenthesis to indicate the

type of well. Wells are classified according to the purpose of the drilling or activity pertaining to a well as follows:

Exploration -	(E)
Confirmation -	(C)
Development -	(D)
Injection -	(I)
Reworked Well -	(R)
Abandoned Well -	(A)

11.3.2 Reporting Bottom Hole Locations of Directionally Drilled Wells

The bottom hole location of all directionally drilled wells will be described as a direction and distance from the surface drilling site. Prior to initiating drilling, a "target" location for the bottom hole will be reported. Upon completion of the well, the actual bottom hole location and depth will be reported.

11.4 Sequence of Drilling

Drilling sites will be occupied in a sequence that will best accomplish the objectives of the project. Previous drilling results will have the most significant influence on selection of subsequent drilling sites and bottom hole targets.

Site specific environmental considerations may also influence drilling sequence and alternate site locations.

The initial drilling permit application will be filed with DLNR for drilling of 12 exploration or development wells at selected drilling sites in the conservation district portion of Kahauale'a. It is expected that at least two of these wells will be converted to injection wells.

The first exploration well in the project area will be drilled vertically. Subsequent exploration wells will be drilled vertically, or directionally, depending on the results of previous drilling. Confirmation and development wells will be drilled directionally wherever feasible.

The plan to occupy another drilling site will be reported as soon as such determination can be made based on results of previous drilling. The plan to initiate drilling of a subsequent well within a drilling site will be reported in accordance with Rule 183-65, Chapter 183, HRS.

11.5 Rate of Development

In the initial stages of implementing the Master Plan, development drilling will progress at a rate that reflects existing or firm future demands for electrical power. Because of the current minimal requirement for additional power on the Big Island and the minimal base load HELCO can initially accept from a geothermal power source, the first phase of development drilling will be limited to that required to produce sufficient resources to supply a 25 MW power plant. Depending on the quality and quantity of the resource, approximately 8 development (production) wells would be required to supply a plant of this capacity. The drilling required to provide this quantity of resource (up to 12 wells) could be completed within approximately 24 months. Changes in market projections or demand would require reevaluation of development drilling plans.

11.6 Development Areas

Drilling sites are initially planned as indicated in Appendix C. Power plant sites, roads, and gathering system pipelines have been located and spaced in appropriate proximity to the drilling sites. The initial development area is expected to be in the area of

Power Plant "A" site which should be within acceptable fluid transmission distance of 10 drilling sites. The nature and timing for activity in other areas will depend on drilling results and market development. Some redundancy in the gathering system pipelines is planned, when feasible, between development areas.

12.0 DRILLING OPERATIONS

12.1 Drilling Rig Capacity and Description

The proposed drilling rig to be used is capable of drilling to depths of 13,000 ft. using 4-1/2" drill pipe with 3-1/2" drill pipe below 11,000 ft. The proposed drilling rig consist of the following or comparable components and auxiliary equipment:

National 50-A Drawworks with 40" double hydromatic brake with two Waukesha F2896 DSIU Engines rated 500 HP each.

Twin disc fluid couplings.

Lee C. Moore Jackknife Derrick (131' x 18') capable of stringing up six to eight lines. 16' clearance under rotary beams. Capacity is rated as 750,000#.

National K-700 Mud Pump (7" x 16") driven from compound. (capacity: 600 GPM)

National C-250 Pump (7-1/4" x 15") driven from compound. (Capacity: 400 GPM)

Ideco Rotary Table (27-1/2") driven by the drawworks.

Shaffer Type B Double Gate Blowout Preventer (12"-900) 5000# working pressure, with 900 series flanges, hydraulically operated.

GK Hydril Preventer (12"-900).

Rotating Head (12"-900).

200 KW Three Phase 110-220 AC Generator.

125 KW Three Phase 100-200 AC Generator.

Hutchinson Vapor Proof Lighting System.

Three Steel Mud Tanks 5' x 8' x 28'.

Link Belt NRM 145 4' x 5' Shale Shaker.

3 Cone Desander.

A mud system capable of circulating 500 barrels of fluid with 1 shale shaker and 400 barrels of mud in storage.

Bear Automatic Driller.

TOTCO 3 Pen Recorder.

11,000' 4-1/2" OD 16.60# Grade E drill pipe with 6" OD API extra hole tool joints.

18 6-3/8", 6-1/2", 7" OD x 2-13/16" ID x 30' long drill collars with 4-1/2" extra hole tool joints.

450 Bbl. Water Tank.

Trailer House.

(The drilling rig, auxiliary equipment and supplies described above will be transported from the Mainland to Hilo Harbor in 40 to 50 trailers.)

12.2 Transportation Equipment

Transportation of the drilling rig, auxiliary equipment and supplies into the project area will require 3 axle trailers with tandem tractors to haul loads up to 40,000#. Local truckers and cranes will be used. Transfer of all equipment and supplies to the project area is expected to take 3 days.

12.3 Drilling Program

Drilling operations will be conducted by a 15 man crew on a 3 shift basis of 5 men each; drilling supervisors and geologists will direct the operations.

The drilling program is usually divided into phases according to the type of drill pipe or casing installed at various depths. All geothermal wells will be cased with standard drill pipe to protect the environment, ground water resources, geothermal resources, life, health and property. Casing is normally classified according to depths installed or function as follows:

- (1) Conductor pipe. The first string of pipe installed, normally 20" diameter to 150' (100 lbs./ft.) set in 26" hole.
- (2) Surface casing. 13-3/8" diameter API grade to 2,500' (50 lbs./ft.) set in 17-1/2" hole.

- (3) Intermediate casing. 9-5/8" diameter to 3,600' (36 lbs./ft.) set in 12-1/4" hole. Set with hanger in 13-3/8" casing.
- (4) Production liner. 7" diameter from the top of producing interval to total depth installed in 8-3/4" hole. Also will be set with hanger in 9-5/8" casing.

(Figure 9 shows the basic elements of a rotary drilling rig.)

Each well will have a casing head installed on the surface casing; to this a Master Gate will be installed which will be left on the well. In addition, a hydraulically operated Master Gate with annular preventor will be installed; when air drilling is being conducted a rotating head will be installed for positive control.

12.4 Air/Mud Drilling

Depending on the sub-surface geology, it is planned to drill with air from the surface to total depth using 2 low stage compressors with 1,200 C.F.M. and 1 high stage compressor for pressure up to 400 psi providing the formations drilled are compatible. Air drilling is successful in hard rock where there is no influx of

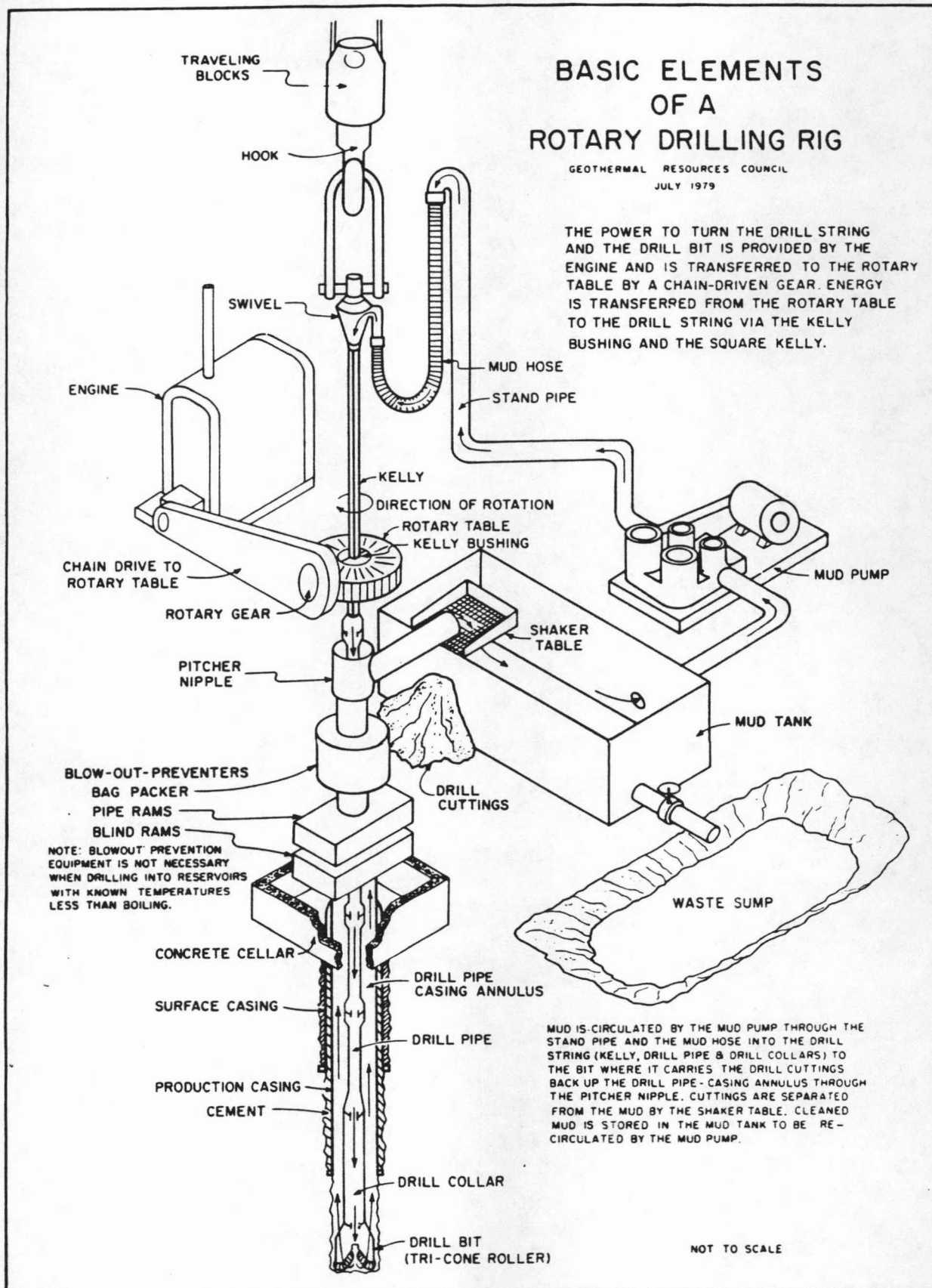


FIGURE 9

formation waters. When air drilling is not possible, mud drilling will be conducted using the lowest weight per gallon ratio possible and the least viscosity possible to remove the cutting from the formations drilled. (For example: we would use a weight per gallon ratio of 9-9.5 lbs. per gallon and 30 to 40 viscosity.) For drilling in the softest formations, approximately 2,000 barrels of water per day would be required; or, approximately 100 barrels per day in hard formations.

12.5 Cementing

All casing will be joined and cemented to assure the integrity of the well bore from surface to the producing interval. The objectives in cementing the casing are to completely in-fill the cased and open hole annuli to resist land sliding and ground water movement and to anchor the casing sections to each other and to the ground. The cement sheath will protect the casing against possible corrosion by thermal brines and gases, prevent uncontrolled flow of thermal water and steam outside the casing, and minimize creep due to thermal expansion. Casing will be cemented using Type G cement from bottom of casing to surface in accordance with industry standards. The 9-5/8" casing

will be landed with hanger, cemented from hanger point to top of producing interval. The 7" liner will be landed with hanger, from base of 9-5/8" casing to total depth. This liner will not be used if experience shows it unnecessary.

12.6 Blowout Prevention Equipment

The following standard safety devices will be used to protect against a blowout from the well:

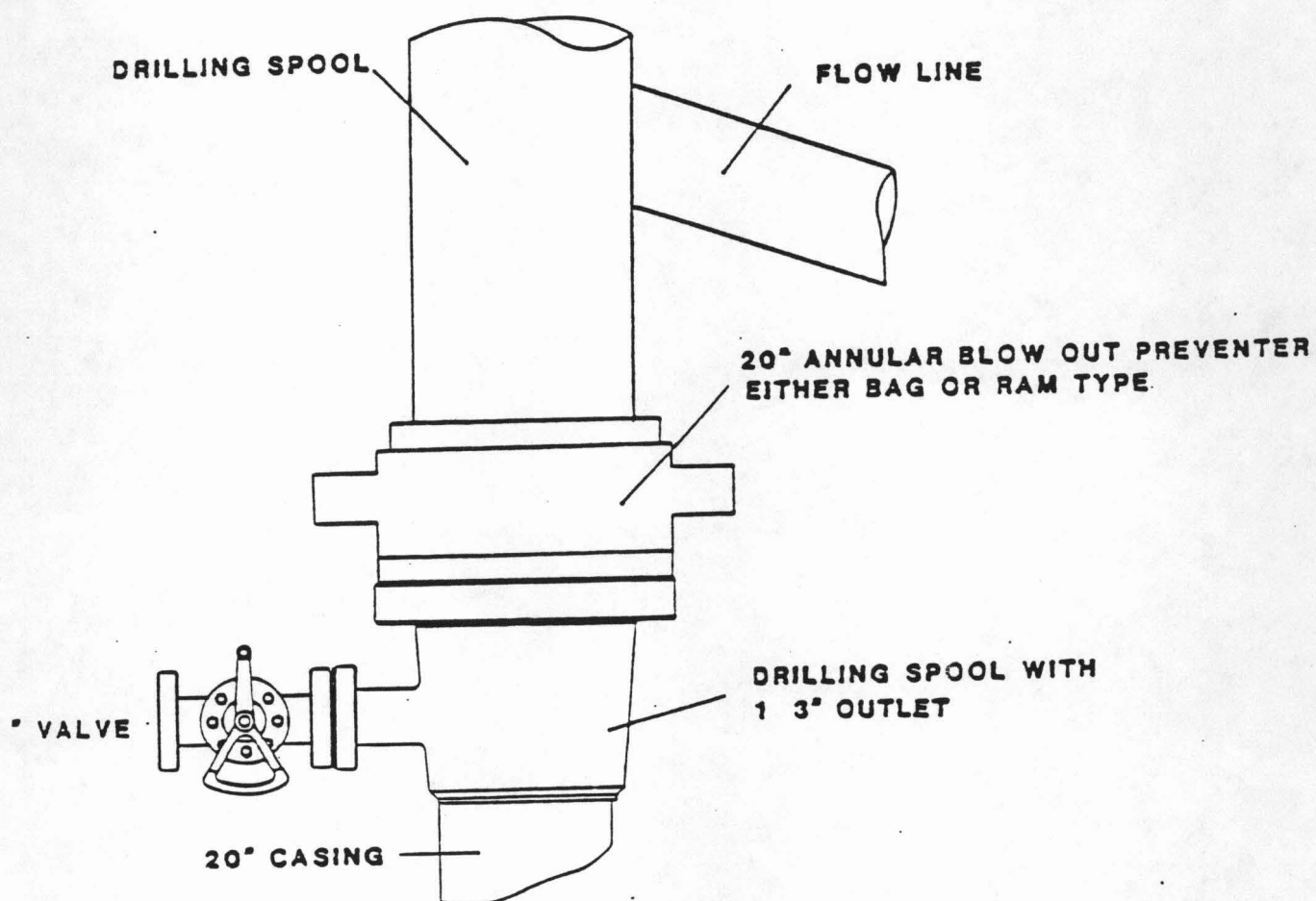
- 1 Double Gate preventer with C.S.O. rams plus 4--1/2"drill pipe rams, 12"-900 series.
- 1 Annular Preventer 12"-900.
- 1 Rotating Head when air drilling.

A blowout prevention system is individually designed for each casing string that is cemented to the service. Figure 10 shows a conventional system for drilling the surface portion of a hole. Figure 11 illustrates a typical system designed for production hole drilling, and Figure 12 shows a typical blow out preventer system designed for high pressure wells.

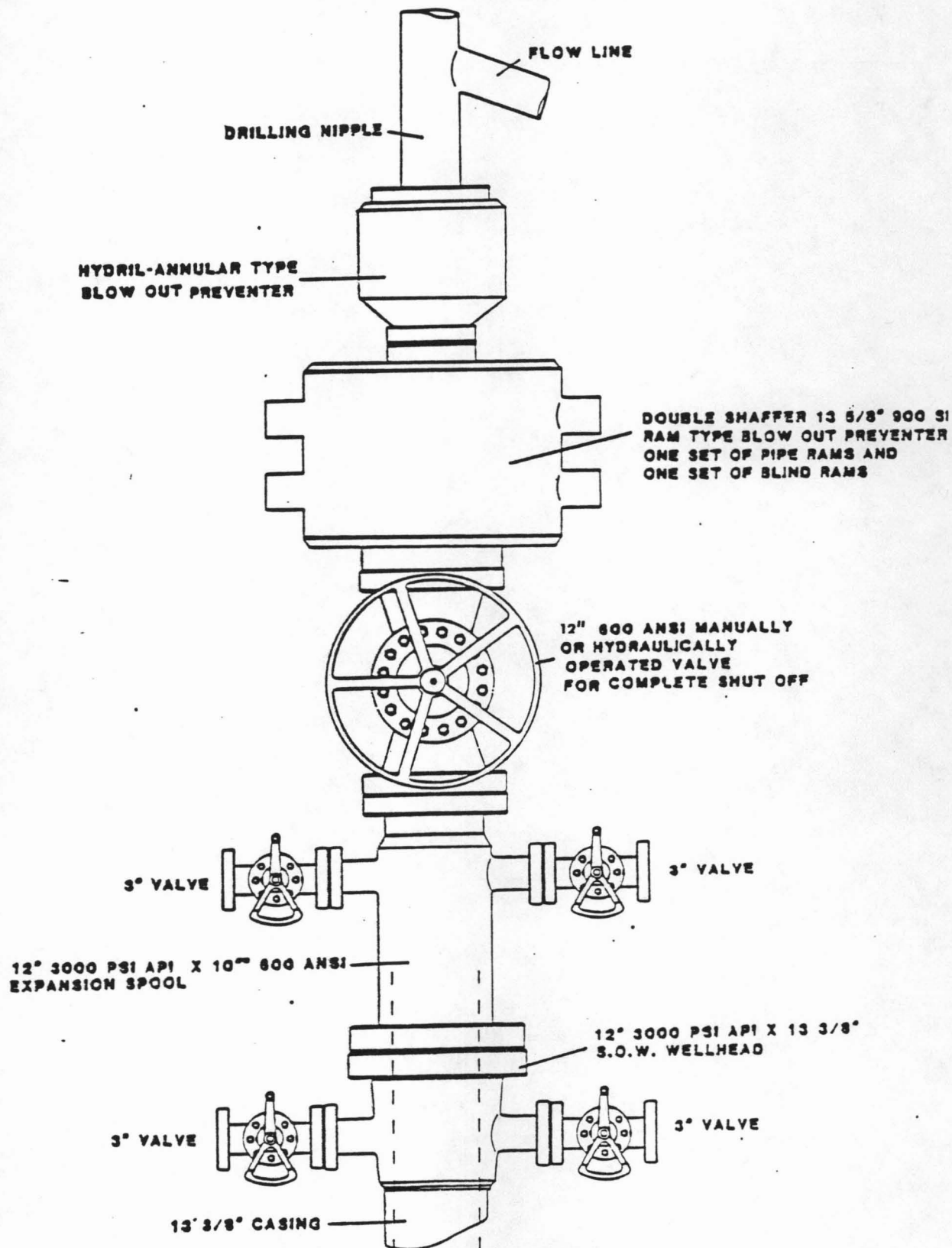
12.7 Logging

- (1) Mud return temperature will be recorded by instruments at all times when heat is expected.
- (2) Logging will be accomplished using standard E logs, plus Resistivity and Gamma Ray logs with Caliper and Temperature logs, provided that hole temperatures are within the tolerance of available instruments.

BLOW-OUT PREVENTER SYSTEM FOR SURFACE HOLE DRILLING



BLOW-OUT PREVENTER SYSTEM FOR PRODUCTION HOLE DRILLING IN A HOT WATER PROSPECT



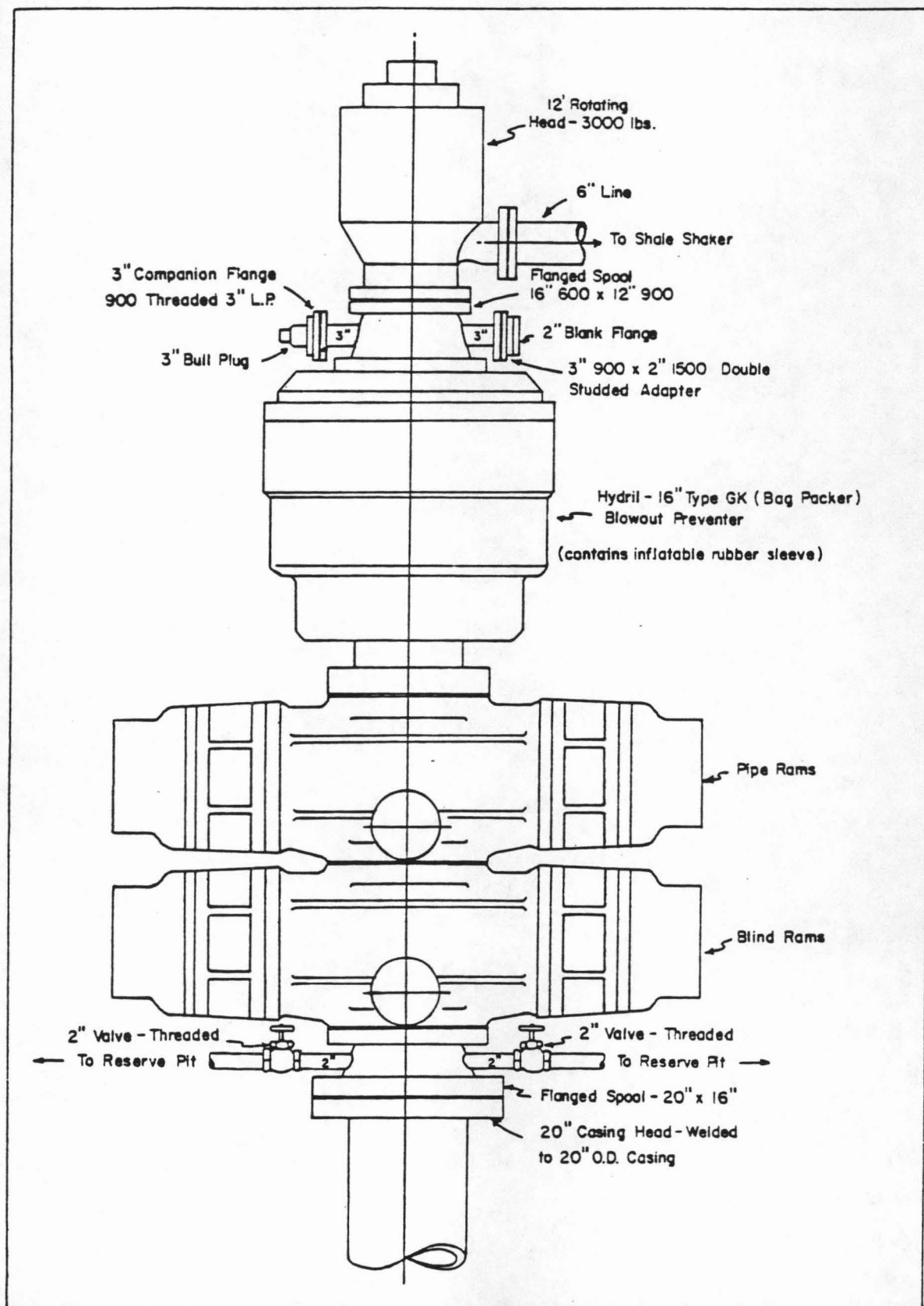


FIGURE 12. Containment equipment--blowout preventers. Typical for use on high-pressure wells.

12.8 Safety

Safety is stressed in all aspects of this type of operation. All employees are and will be instructed in closing and opening blowout preventers (B.O.P.s) which will be hydraulically operated. The operator has an on-the-job training program using video tapes and projectors pertaining to safety, B.O.P.s and maintenance, etc. (True Drilling Company has been awarded the International Association of Drilling Contractors Safety Commendation Award for each of the past seven years.

12.9 Emissions Control and Environmental Monitoring

Hydrogen sulfide (H_2S) is known to be associated with hot springs and fumarole activities throughout the world. In geothermal development, it is a constituent of the fluid in varying degrees as a non-condensable gas. Abatement systems will be designed to control H_2S emissions during extended well testing and for power plant operations. The operator will have H_2S detectors mounted at different locations about the drilling rig for emission monitoring and controls. In addition, environmental stations will be established to monitor the effects of any sustained operations in the area.

12.10 Noise and Dust Control

All of the engines on the drilling equipment are equipped with mufflers. Noise and dust from air drilling will be controlled through use of a sparging pit. Also, the roads to the location will be monitored to control dust. Water sprinkling will be carried out as needed.

12.11 Well Records

While drilling, all data will be recorded in duplicate. All formations will be logged by a well site geologist. Summary reports will be made available upon completion of each well, as well as standard well completion reports.

12.12 Mud Tanks and Pits

The rig to be used has 3 steel mud tanks with 750 bbl capacity each; also an earthen reserve or storage pit will be dug and lined to handle excess fluid.

12.13 Abandonment

Upon determining that a well must be abandoned the operator will analyze data from the logs to determine what formations are required to be covered by cement.

The plugging will be performed through open ended drill pipe using type G cement in accordance with industry standards. After the down hole plugging is performed a cement plug will be placed in the top of the surface casing.

12.14 Liability

The operator carries necessary liability insurance to cover any operations in connection with the drilling and completion of the wells.

13.0 WELL TESTING AND RESERVOIR EVALUATION

13.1 General

The viability of the project after discovery of a resource will be determined on whether characteristics of the geothermal reservoir and fluid are suitable for generating electrical power and the price received for that power. In essence, the following criteria are evaluated to determine the potential of a reservoir to support a power generation operation at full capacity for 25-30 years:

- (1) Depth and sub-surface structure
- (2) Temperature of the fluid
- (3) Flow rate of each well

- (4) Chemistry of the geothermal fluid
- (5) Reservoir and production zone dimensions (reserves)
- (6) Reinjection potential

Figure 13 shows a schematic of a geothermal reservoir.

13.2 Testing and Evaluation Procedures

Testing of the wells will follow a procedure similar to the most recent test of the HGPA well in Puna in which both noise and environmental pollution abatement was accomplished by use of a "sparging pit" and the injection of caustic soda to remove unwanted hydrogen sulfide gas. Tests will also be conducted on the integrity of the well to bottom hole through casing, logging of the cementing tests, and pressure testing.

After each well is completed, an initial test by accepted industry methodology will be conducted to get an approximation of its electric power production potential. If it is judged to be a commercial producer, portable flow testing equipment will be installed to acquire a full suite of data on the physical and chemical characteristics of the reservoir fluids. This will include a flash steam separator, skid-mounted flow metering and temperature measurement equipment for steam and brine, noncondensable gas sampling equipment, and injection and mixing

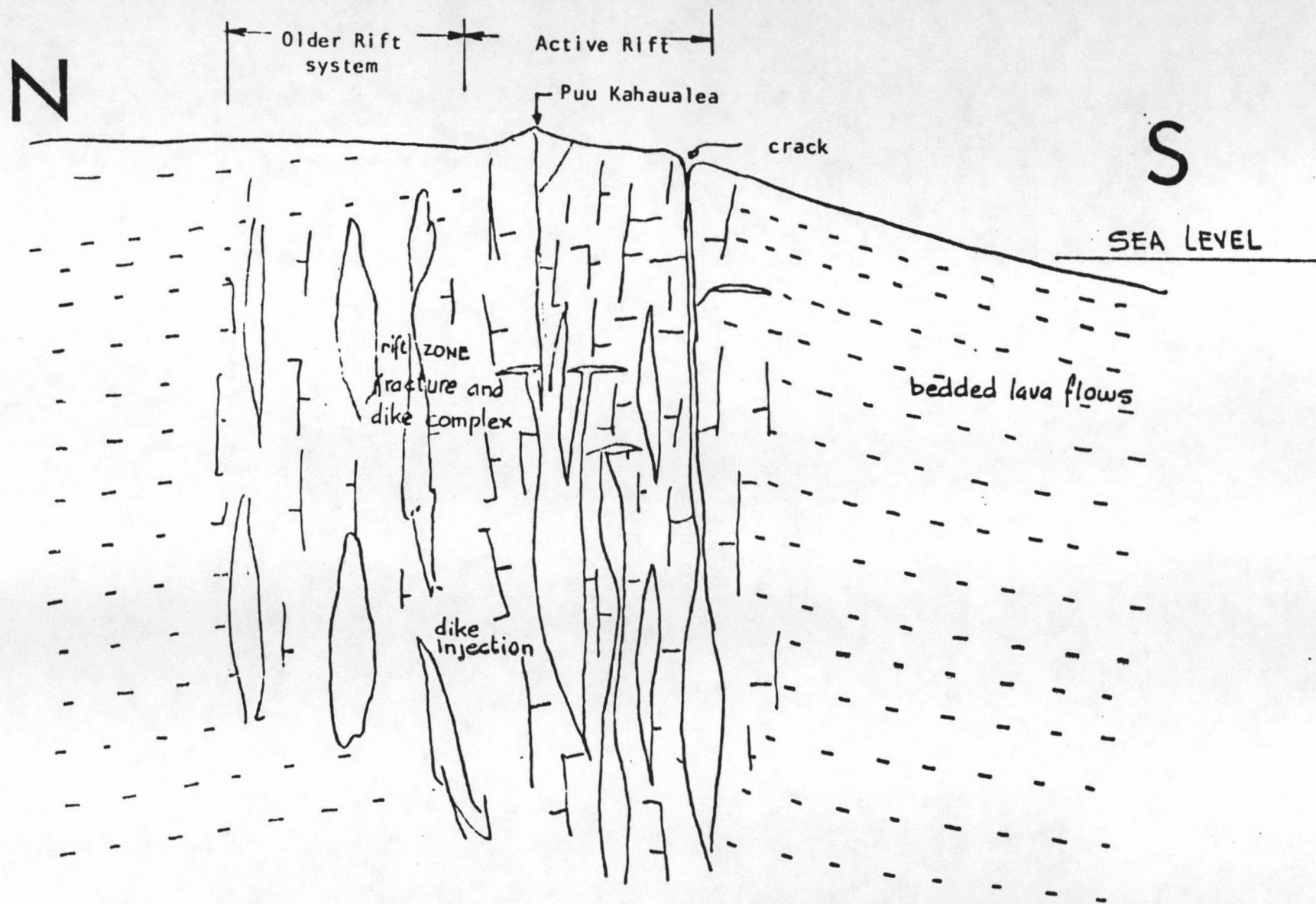


FIG. 13 Cross Section, Perpendicular to the Rift showing a Rift Zone Fracture and Dike Complex as expected beneath the Kahaualea Property

equipment for H_2S abatement with caustic soda.

A warm-up pond or reserve pit will be constructed at each producing well to receive the brine flow during the production tests. The project's environmental specialists will evaluate the reservoir fluids from each well and will consult with the appropriate regulatory agency to determine whether the brine can be percolated into the ground or pond liners will be required. Due to the highly porous nature of the top soil and near-surface formations, fluids should percolate readily into the ground. The chemistry of the well fluids are expected to be relatively benign, if similar to the HGP-A well, and should have no adverse impact on the basal water table at seal level.

During the production test, engineers will monitor the production rate, steam-water ratio, hydrogen sulfide content, salinity, fluid chemistry, and noncondensable gas content. All of these items are necessary to design an appropriate power plant and to devise an appropriate means of protecting the surface and subsurface environment, and will provide a data base that is necessary in order to satisfy HECO, or other user, that the resource and its producibility are totally acceptable as an alternative energy source and that the

potential for producing up to 250 MWe from the Campbell property can be realized.

When a minimum of three successful wells have delineated a potential reservoir of sufficient size, interference tests will be run to establish intercommunication within the reservoir and provide the necessary engineering data to assess volume of the geothermal fluid reserves, the available heat, and the estimated productive life of the reservoir. A competent geothermal reservoir engineer will be engaged to independently assess the geothermal energy potential.

14.0 WELL-FIELD PRODUCTION SYSTEM

14.1 General

The well-field production system for this plan as fully implemented would consist of 5 separate field (development) production areas comprised of production wells, well head equipment, pipelines and disposal systems managed through an integrated operations and maintenance system. The power plant element of the project is described in paragraph 17.0. For all practical purposes, the well field production systems for

each area would be essentially the same except where applications of new technology are made. This section will describe the type of well field production system we envisage for the initial development activity within the leased property.

The initial production is realistically planned to meet the current and near term market requirements projected by HELCO and to expand production capability as rapidly as HELCO can accept additional power. For this reason, our production plan during the first two years is to develop sufficient resources to supply a 25 MW power plant in two increments of 12.5 MWe power plants; the first in 1985 and the second in 1987.

Resource production from three active wells and one reserve (spare) well are projected to be required to support installation of a 12.5 MW power plant. The disposal of residual brine after production steam removal would require one injection well.

The second 12.5 MW generation to be installed would be included in the initial complex with minimal additional equipment. However, 5 more wells as described above would be required.

14.2 Replacement Wells

The geologic and geohydrologic characteristics of the Island of Hawaii are unique in comparison to other producing geothermal resources in the world, therefore it is not possible at this stage of experience with the Puna geothermal system to predict the long-term response of the wells to sustained high volume production. However, we consider it prudent to budget our development on the assumption that the reservoir behavior will be similar to that of other hydrothermal resources where individual well production is known to decline with time.

There is little published data available on production histories of the various reservoirs; however, based on a study of the Cerro Prieto field in Mexico by J. de J. Sanchez R. and A. de la Pena L., we are assuming a requirement of two replacement production wells and one replacement disposal well for each 12.5 MWe plant over a 30-year period.

Figure 14 shows a profile of a typical geothermal production well.

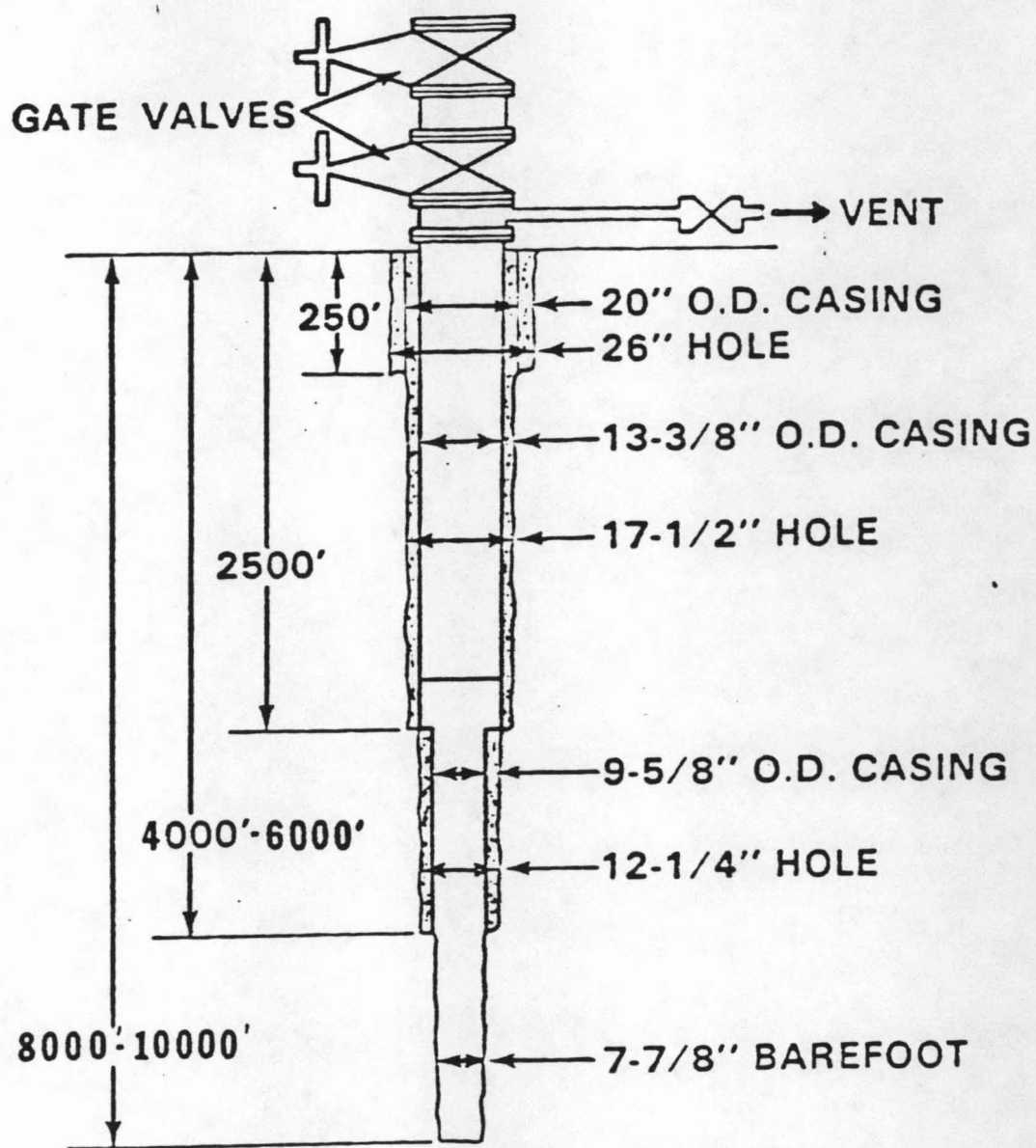


FIGURE 14 TYPICAL WELL PROFILE

14.3 Warm-Up Ponds and Pump-Out Lines

Warm-up ponds used during initial production testing as discussed in para. 13.0 above will become part of the field production system for a well or groups of wells. In normal production operations, each warm-up pond will accommodate sufficient geothermal brine flow during well start-up to permit bringing flow up to operating temperature before routing it through the gathering system piping. The ponds may also be used during periods of temporary well shutdown in order to avoid completely shutting in the well with the resultant loss of heat and necessity for repeating the warm-up process.

Small diameter non-metallic pump-out lines, approximately 102 mm (4 inches), will extend from each well site warm-up pond to the main plant start-up pond utilizing supports provided for the gathering system piping. Pump-out of ponds will be accomplished by means of a portable engine-driven pump moved by maintenance personnel. The individual warming ponds will be pumped into the main plant bypass pond.

The power plant bypass pond will provide storage capacity for brine during plant start-up until such time as flow is satisfactory for routing through the separators

and into the turbine. Additionally, the cooling tower blowdown will also be passed into the bypass pond and transferred to the silica drop-out system. A booster pump will deliver brine from the pond to the suction of the injection pumps.

14.4 Gathering System for Geothermal Fluids

14.4.1 Design Considerations

The design of the gathering system that will carry the geothermal fluids to supply the power plants will be based on the following resource characteristics:

- (1) Enthalpy (downhole)
- (2) Wellhead Pressure
- (3) Wellhead Temperature
- (4) Flow Rate
- (5) Well Spacing
- (6) Projected Well Flow Decline with Time
- (7) Reservoir Chemistry

14.4.2 Two-Phase Flashing Flow Design

Based on what is known of the resource discovered at the HGP-A well, it is expected that the gathering system selected to collect the hot geothermal brine will consist of a pipeline network designed for two-phase

flashing flow from the well sites to a flash steam separator at the power plant. Considerations of topography, flow characteristics, and economy in the pipeline network will be utilized to optimize the final design of the network.

The two-phase flashing flow design simplifies the gathering process by not requiring wellhead or satellite separators, and eliminates the need for two pipelines.

Substantial cost advantages result in utilizing and optimizing this single pipeline gathering system. Two-phase flow experiments conducted by Mitsubishi Heavy Industries and Kyushu Electric Company as part of the design of the 50 MW Hatchobaru geothermal power station in Japan have demonstrated the feasibility of two-phase gathering systems over a wide range of transient flow conditions.

14.4.3 Pipelines

The gathering system piping will be of carbon steel, 4 to 6 ft. above ground, mounted on saddles, with anchors and expansion loops as required by dynamic forces and thermal movements. The gathering system piping will be insulated to minimize heat loss. Typical sizes are

expected to be 16 inches to 22 inches diameter.

Additional lateral restraints may be required to protect against possible lava flow hazard.

14.4.4 Flash Steam Separation Equipment

The primary component involved in the flashing process is the separator (or flash tank). Mixed brine and steam flow enters the separator at the inlet from the gathering main, and that portion of the flow flashed to steam is directed to the single stage turbine. All unflashed brine flows to the silica drop-out pond and then to the suction header of the injection pumps.

The separator has provisions for pressure control and is equipped with safety relief valves which open in the event of a turbine trip or other occurrence causing the main steam stop valves to close.

14.5 Disposal (Injection) System

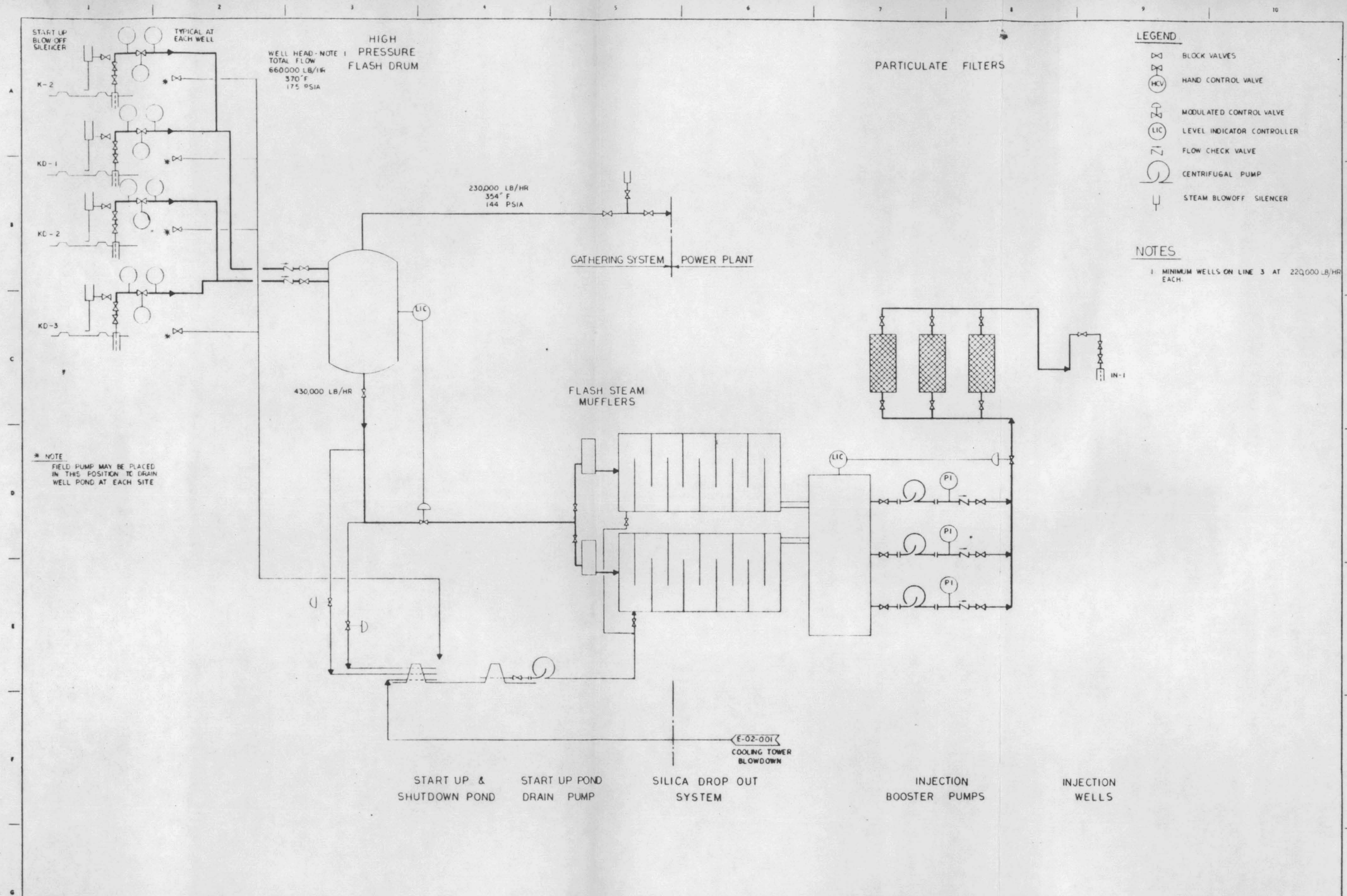
Hydrothermal fluids with chemistry similar to that expected to be found at the Campbell Estate property are known to begin precipitating silica as they cool below 150°C. Because the residence time in the flashing equipment will be less than three minutes, only a nominal amount of silica scaling is expected at

this stage. However, to eliminate plugging in the injection piping and wells the brine would be cooled in ponds to drop out silica prior to transfer to the injection pumps. The cooled brine would then be mixed with the spent caustic stream from the H₂S abatement system and the neutralizing cooling tower blow down and pressured through polishing filters. This silica system will be sized to provide an hour's residence time and cooling to about 70°C.

14.5.1 Injection Pumps

Injection pumps at the power plant will return effluent from the silica drop out system and transfer clear effluent into the ground at a suitable injection site near the geothermal reservoir.

The injection pumps will receive effluent primarily from the flash separator, the cooling tower basin blowdown pumps and the bypass stream H₂S abatement system. The pumps will be rated to deliver effluent through the solids polishing filters and then to the wellheads at a wellhead pressure which is adequate to inject the design flow into appropriate geological formations. Drawing No. E-03-002 illustrates the gathering and injection system and contains design flow parameters.



REFERENCE DRAWINGS				REVISION				REVISION			
1	2	3	4	5	6	7	8	9	10	11	12
ROGERS ENGINEERING CO., INC.				TRUE/MID-PACIFIC VENTURE				PROPOSED 12.5 MW GEOTHERMAL POWER PLANT			
ENGINEERS - ARCHITECTS				PUNA DISTRICT HAWAII				GATHERING & INJECTION SYSTEM			
111 PINE STREET, SAN FRANCISCO, CALIFORNIA 94111				DATE 6-20-01				FLOW AND CONTROL DIAGRAM			
SCALE NONE				APPROVED				JOB NO.			
DR. HAYAL				E-03-002				REV.			
E-03-002				0							

14.5.2 Injection Wells

Injection wells will be required to dispose of the residual fluids of geothermal power generation to avoid environmental degradation to the area, and to minimize temperature loss within the production field.

It is estimated that 65 to 75% of the original reservoir fluid will be available for injection. It can be assumed that a disposal well will consume more fluid than a production well can produce because of the added effect of the hydrostatic column of water. Thus, only one disposal well may be required for every three operating production wells.

14.5.3 Disposal Well Criteria

Several criteria for disposal wells can be stated in approximate order of importance:

- (1) On the basis of flow and interference tests there should be direct rapid communication between injected fluid and production wells.
- (2) Disposal zones should be at least as deep as production zones, to allow for re-heating and upwelling of the injected fluid. This will enhance the maintenance of reservoir mass and pressure, with minimum loss of temperature.

Disposal depth must be set at a distance below fresh water aquifers to avoid degradation of the quality of these waters.

- (3) Disposal wells, wherever possible, should be down slope of the power plant, to allow for gravity-flow disposal, at significant savings in energy.
- (4) Unsuccessful wells should be used wherever possible as injection sites rather than drilling additional disposal holes. This will reduce the drilling costs significantly as well as the environmental impacts of drilling.
- (5) Disposal wells should be located at, or close as possible to, the power plant, to reduce pipeline costs and the amount of disturbance to the land.

14.5.4 Selection of Disposal Well Sites

From these criteria it can be seen that disposal sites should not be selected until well testing is completed. If long-term tests show that there is no direct communication between holes in some quadrant of the field, unsuccessful wells in that quadrant can be converted to disposal wells if permeability is adequate. This would be the most economical solution to disposal.

Otherwise, sites would be selected at or just beyond the field margins, utilizing down-hill flow at short distances from the power plant. Disposal wells would be drilled at these sites. This highlights the importance of drilling field boundary-definition wells along with production wells. Non-production boundary-definition wells may be most easily converted into disposal wells. Productive boundary-definition wells will serve to extend the field and increase the estimated reserves of geothermal energy.

14.5.5 Disposal System Pipelines

Similar to the gathering network, the injection system piping will be of carbon steel and mounted above ground. All piping will be nominally insulated as required, to preclude temperature degradation which leads to scale build-up in the injection system piping, and for protection of personnel.

14.6 Steam Production Turndown

In the event of unexpected drops in power demand, load shedding would require some venting of production steam, which would have separate abatement equipment for H₂S control. The H₂S abatement of the bypass steam will be accomplished by neutralizing with caustic soda

in a scrubber. The H_2S would then be injected in the chemically-bound condition as sodium sulfide (Na_2S) together with the effluent from the main scrubber.

Due to the remoteness of the proposed plant site and the densely forested nature of the terrain, the normal noise attenuation provision for geothermal power plants is expected to suffice to guard against any adverse environmental impact from any bypass flow of a portion of the resource production.

15.0 Environment Considerations

15.1 General

Inasmuch as the Campbell property is classified as "conservation" and because of its proximity to the Volcanoes National Park, an Environmental Base Line Study of the property in relation to the development plan was conducted by Dr. Barbara Siegel and Dr. Sandford Siegel, botanists under contract to Mid-Pacific Geothermal, Inc., through their consulting firm, Ecotrophics. This data together with the deve-

lopment plan provided the basis for an Environmental Impact Statement which will be prepared by R. M. Towill Corp. The Environment Impact Statement will address all anticipated impacts from full development of the property to a capability of producing up to 250 MWe. All known and required measures which must be taken to protect the environment are addressed. Based on data obtained thus far from the HGP-A well, together with data accumulated for the EIA, and from other geothermal developments in other parts of the world, it appears there are no negative impacts which can't be resolved or mitigated to acceptable levels.

15.2 Emissions

Some of the planned well sites and power plants will be less than one mile from the boundary of Hawaii Volcanoes National Park. The Federal Clean Air Act, as amended, governs the emission standards for Class I areas. The magnitude of the natural emissions along the active rift zone passing through Kahaule'a and from Kilauea Crater will be recorded prior to commencement of any drilling operations on the property. Under the Act the EPA Region IX, San Francisco, California, has promulgated regulations governing the enforcement in the region that includes Hawaii. The local agencies

having jurisdiction are the Hawaii Department of Health and the County of Hawaii. The environmental specialists for this project will consult with these organizations to determine the level of emissions to be permitted by the project, and to establish base line data and monitoring procedures.

It can be expected that the geothermal fluids produced from the east rift zone of Kilauea will contain varying amounts of hydrogen sulfide (H_2S) depending on reservoir locations. Moreover, the H_2S content is likely to exceed that which can be directly discharged to the atmosphere over time without exceeding acceptable air quality standards. Hence, power plants will be designed to incorporate H_2S primary and secondary abatement systems to maintain acceptable air quality standards. (The Stretford process and a secondary process based on oxidation of the H_2S with hydrogen peroxide plus a catalyst are being successfully used at the Geysers in California.)

According to the current experience of other geothermal power plants in the United States, including the HGP-A well in the Puna District, adequate emission control equipment and procedures are available to meet existing standards, so no difficulty is anticipated for this project in this regard.

However, the method of abating H_2S for the 55 MWe units will be different from that used in the HGP-A plant and the 25 MWe plant. In the smaller plants a higher operating cost is accepted in preference to the relatively large capital cost of the alternate process. In the 55 MWe size, however, the economics are in favor of installing process equipment to take advantage of lower cost of treatment chemicals plus a salable by-product. There are on-going programs of active study of alternative methods of H_2S abatement, and it is possible that additional improvements in the state-of-the-art may be available by the time the 55 MWe generating units are built at Kahauale'a. Drawing No. E-02-002 illustrates the gathering and injection system flow and control diagram for a 55 MW plant.

16.0 HAZARDS TO OPERATIONS AND PERSONNEL

16.1 General

Geothermal resources in the Puna district owe their existence to the recent volcanic activity of the region. Without this constant "resupply" of heat to the system, it is unlikely that the resources would

be as extensive as they are thought to be based upon the results of HGP-A. This volcanic activity that is responsible for the resource also creates a certain degree of hazard in the form of earthquakes and the risk of volcanic eruption. Any geologically young area has similar risks, e.g., the San Andreas Fault system in California that affects the cities of San Francisco, and Los Angeles as well as the geothermal development in the Imperial Valley; the volcanoes of the Cascades, Central America and the Philippines, the latter two of which have successful geothermal plants in the shadows of the active volcanoes, and Iceland where the geothermal plants are on an active rift zone considerably more hazardous than any in Hawaii. The issue is not to avoid geologically young areas, but to use adequate safeguards in the detailed evaluation to reduce the risk to an acceptable level.

Any area with young geologic features has concomitant geologic hazards and Kilauea volcano is no exception. The primary hazard along the rift zone consists of earthquakes, lava flows, eruptions, and sudden ground movement (subsidence) associated with faulting. Although these hazards are present, the economic risk is probably small as is discussed below. Subsidence due to the removal of geothermal fluids is not a con-

cern in Hawaii due to the massive nature of the rock in the reservoir. Production is expected from fractures and intrinsic porosity of the lava and not from sands as is the case on the Mainland where subsidence problems have been encountered.

16.2 Earthquake

16.2.1 Earthquake Hazards

The largest earthquake in the recent past was the Kalapana earthquake of 1975 ($M=7.2$). Smaller earthquakes occurred in 1954 ($M=6.5$), in 1951 ($M=6.5$ and $M=6.9$), in 1929 ($M=6.5$), and in 1868 (large but magnitude unknown). Despite the size of these earthquakes, little structural damage occurred and accelerations rarely exceed $0.4g$. These accelerations have a peak amplitude response primarily in vertical direction. In a risk analysis for the University well site (Rogers Engineering, 1978), it was recommended that the design criteria for primary components (components whose failure involves severe economic loss or possible loss of life or severe injury) be adequate to withstand a ground acceleration of $0.41g$ with a response spectrum peaking at approximately 4 Hz. These characteristics were recommended on the basis of a 30-year design life and an assumption that it was acceptable for the ground

acceleration to exceed 0.41g with a probability of 10 percent in the 30-year period. This criteria would be comparable for the Campbell Estate and presents no real problem relative to power plant design.

16.2.2 Earthquake Hazard Abatement

Abatement procedures for seismic hazards are well known from experience in other parts of the world where seismic hazards exist. These experiences suggest that a design criteria of 0.5g vertical acceleration with peak amplitude at about 4 Hz and having a maximum particle motion perpendicular to the rift zone would be appropriate. Moreover, the axis of the generator should probably be approximately parallel to the rift system.

16.3 Volcanic Eruptions

16.3.1 Potential Hazards from Volcanic Eruptions

Volcanic hazards within the rift zone can be divided into two categories: (1) Those due to events taking place in the immediate vicinity of an eruption and (2) those that are associated with the downslope movement of lava issuing from a vent. The best, and perhaps only, way of mitigating the first hazard is to locate the physical facilities outside the zone of potential

active eruptive activity. We envisage constructing power plants in such areas and, if our exploration program is successful, we would hope to have a substantial portion of our production from areas outside the currently active rift zone as well. Within the rift zone itself, past eruptions have been frequent in some areas and virtually absent in others. Thus, even within the rift zone there are areas where the hazard due to eruptive activity can be minimized, perhaps to the point of being insignificant. These areas, while having a low hazard relative to eruptive activity, have a high hazard relative to lava flow for the lava flows tend to pond and flow within the rift zone area. Outside of the rift zone, there is still a significant hazard due to flowing lava. The use of artificial barriers or construction on high ground tends to minimize this hazard. According to the Rogers Engineering (1978) report 3 to 8 percent of all the land area within the rift zone is likely to be buried by lava flows in any given 20 year period, while only 0.5 to 3 percent of all the area outside the rift zone would be covered during the same period. Thus, location of the major facilities outside the rift zone, particularly if the location is in an area of high ground, should provide an adequately low risk for a major investment.

16.3.2 Hazard Abatement Procedures from Volcanic Eruptions

Abatement procedures against volcanic hazard thus consist of (1) locating all major facilities north of the active rift zone, preferably on high ground; (2) constructing barriers on the uphill side of the facility; (3) placing major facilities on raised platforms; or (4) placing critical components in buried cellars that lava cannot enter. The preferable procedure for the power plant is of course procedure (1) while the wellheads can best be protected by procedure (3) or (4). Close and continuing coordination with the Hawaii Volcanoes Observatory will be maintained to assure that the operator is aware of any conditions which could affect safety of personnel and equipment.

16.4 Ground Subsidence

16.4.1 Relation of Ground Subsidence to Rift Zone

Ground subsidence has historically been limited to the rift zone itself or to areas to the south of the rift zone in the vicinity of the Halini Pali fault zone. Subsidence accompanied by small earthquakes has occurred within the rift zone in 1924 and again in 1955 in association with eruptive activity and occurred south of the rift zone in 1975 at the time of the 1975

earthquake. There is no historic record of subsidence taking place north of the rift zone. Thus, the risk of subsidence should be minimized and not be a significant hazard to a power plant site if the site is located well north of the rift zone.

16.4.2 Subsidence Hazard Abatement

Abatement procedures are therefore to construct the power plant outside the active rift zone. Added safety might require that the design provide for leveling correction of the turbine or that adequate end thrust bearings be installed.

16.5 Volcanic Hazards in the Active Portion of the Rift Zone

The above analysis has primarily dealt with the hazards outside of the active portion of the rift zone. The producing wells and the associated gathering pipeline system may be subjected to all the hazards (earthquakes, subsidence, lava flows) of the rift zone if, by necessity, we are unable to locate a resource outside the active portion of the rift zone. Earthquakes will probably not result in damage to the wells or pipeline with the possible exception that a production well may be severed should a sub-surface fracture intersect the well bore. This is an unlikely possibility but can be

best mitigated through having reserve production wells separated from each other by some distance. The pipeline itself should not be damaged by earthquakes, nor should it be disrupted by heat from lava flows so long as steam continues to flow within the pipeline for it is then essentially self-cooling. Lava flows, on the other hand, could disrupt the pipeline if they become very viscous or blocky, while little disruption is likely to occur if the pipeline is on the surface and is overrun by a very fluid flow. Hazard to the pipelines in areas of potential lava flows can probably be minimized by shallow burial or by surface installation with downslope support structures. Should a pipeline be broken or ruptured, the resource can be closed off at the well head. Since the pipeline must be designed with numerous expansion joints in order to accommodate thermal expansion and contraction, ground subsidence or extension should have little effect on its operation.

16.6 Hazard History in Geologic Time

Recent geologic mappings of Kilauea Volcano by Robin Holcomb of USGS permits a reevaluation of the volcanic hazard maps made by Mullineaux and Peterson 1978. The Mullineaux and Peterson assessment shows the volcanic hazard to be more or less symmetrical about the rift

zone. For the upper area of the rift zone, the surface of the north of the rift zone is 350 to 1,000 years old, as is the surface to the south. Younger units cover substantial portions of the area in the rift zone and to the south of the rift zone but have almost no coverage of this older unit to the north of the rift zone. Thus the data for the past 350 years indicates that there is negligible hazard north of the rift zone in this area. This is in contrast to the case near the HGP-A well site where virtually all the surface is younger than 500 years and more than 50% of the surface is younger than 250 years. This is true even at distances up to 4 miles from the axis of the rift zone. All of the power plant sites for this project have been sited in this region where no lava flows have occurred during the past 350 years.

17.0 GEOHERMAL POWER PLANTS

17.1 General

This section provides general information on the design characteristics and operations of geothermal power plant systems. Power plants to convert geothermal

energy into electrical power will vary in capacity from 25 to 110 megawatts MW of electricity. (1 MW = 1,000 Kilowatts). The first 25MW plant would be constructed in two increments of 12.5 MW each because of the small base load power requirements of HELCO.

Assuming adequate resources and reserves will be discovered, power plant requirements beyond the first 25 MW of capacity will depend on achieving an export capability via an undersea transmission cable from Oahu to the Big Island, or significant increases in electrical power requirements on the Big Island. For either of these eventualities, the next power plant to be constructed is projected as a 55 MW (gross) capacity plant. Approximately 3.6 MW would be used internally for normal plant operations, leaving a net generating capacity of 50 - 51 MW. The requirement for a 110 MW plant would be satisfied by incorporating a second 55 MW within the site for the first 55 MW plant, or using a new site for constructing two 55 MW plants. It appears now that 55 MW units will be the most efficient and economical.

If a producible geothermal resource is discovered throughout the high and moderate resource potential areas as projected, the potential generating capacity

of 250 MW within the project area could be distributed as indicated in Figure 7.

To permit assessment of the impact of power plant construction and operations in the project area, drawings of the smallest and largest operating units planned are included in this plan. These drawings depict plants that have been designed and are in operation. The first design of plants to be constructed in the project area will be based on the nature and characteristics of the resource discovered and will be submitted for review and approval as completed.

17.2 Steam Turbine

(12.5 MW capacity) A single pressure, single flow, impulse type condensing unit with a single cylinder, direct-coupled to a totally enclosed air cooled generator.

(55 MW capacity) A double pressure, double flow, impulse type condensing unit with single cylinder, direct-coupled to a totally enclosed hydrogen-cooled generator

17.3 Turbine-Generator System

(12.5 MW capacity) A single pressure admission condensing unit. The equipment includes all the necessary automatic tripping devices required to protect the unit when a malfunction occurs.

(55 MW capacity) A double pressure admission condensing unit. The equipment includes all the necessary automatic tripping devices required to protect the unit when a malfunction occurs.

The turbine blading will be stiff and short with stress levels considerably lower than those supplied for comparable fossil fuel steam turbines and will utilize those features which will result in long term reliable

service with geothermal steam. Corrosion resistant materials will be specified for turbine internals in contact with geothermal steam.

The generator supplied with the turbine will be designed in accordance with the latest standards of ANSI C50.10-75, and C50-13-1975 and applicable NEMA and IEEE standards.

17.4 Cooling Water System

Makeup water will be provided from the steam condensate.

17.5 Condensate System

The condenser will be designed and constructed, where applicable, to conform with the latest ASME Code and will be of the surface type. The condenser will be constructed of 316 SS clad carbon steel. Internal parts such as tubes and tube plates will be stainless steel. Water boxes will be carbon steel with epoxy coating. The liquid level in the condenser is controlled by automatic liquid level controller. All the condensate from the geothermal steam is to be returned to the cooling tower.

17.6 Auxiliary Systems and Internal Power Requirements

All necessary auxiliary systems will be supplied in addition to the major systems of the power plant, and will be designed specifically for the special conditions imposed by the utilization of geothermal steam and the site environment. The auxiliary systems include, but are not limited to, the following:

Auxiliary Cooling Water System

Turbine-Generator Lubricating Oil System

Instrument Air System

Fire Protection System

Noncondensable Gas Removal System

The turbine-generator lubricating oil system is a part of the turbine-generator supplied equipment.

17.7 Controls and Instrumentation

A main control panel in the control room will contain electrical and pneumatic controls for the various electrical and auxiliary process systems. In general, pneumatic systems will be used for level, pressure, flow and valve controls. Pneumatic transmitters in the field will provide inputs to the panel mounted instruments. Resistance temperature detectors will

provide electrical temperature signals from the field to solid state electronic temperature indicators and controls. Electric control will be used for turbine-generator, switchgear and motors.

17.8 Electrical System

17.8.1 Substation (12.5 MW Capacity)

Electric power generated at 13.8 kV will be transmitted to the transmission line through a main step-up transformer. The transformer will be connected to the line through a group operated disconnect switch which will be equipped with a high speed grounding switch. The grounding switch will be operated only in the event of transformer malfunction. Transmission line faults will be cleared by a 13.8 kV circuit breaker. The transformer will be a standard open busing unit, oil filled and equipped with fans. Space will be provided in the switchyard for a future bus and circuit breakers if found to be necessary.

17.8.2 Station Service (12.5 MW Capacity)

The 13.8 kV station bus will be connected by an air circuit breaker to the generator and the low voltage side of the main step-up transformer. This bus will also supply power to the auxiliary transformer and to

the steam gathering and injection pump system through fused load break switches. The 13.8 kV bus will consist of an assembly of metal-clad drawout circuit breakers and fixed position fused switches. The metal-clad switchgear will have a 500 MVA interrupting capacity. A grounding transformer and resistor will be provided since the main step-up transformer will have a 13.8 kV delta winding.

The auxiliary transformer will step down the voltage from the 13.8 kV bus to 480V in order to supply the 480V switchgear and a motor control center. The auxiliary transformer will be of the unit substation type with fans and a 55/65°C rise. Capacity has been derated due to high ambient temperatures. The various pumps, cooling tower fans, small motors and a transformer for house lighting and other low voltage power requirements are supplied by the 480V motor control center. The 480V motor control center bus will split into a normal and critical load bus. The latter bus has limited capacity and feeds the lighting transformer, air conditioning units, plant sump pumps, turbine auxiliary oil pump, instrument air compressors and other small critical motor loads. This bus will feed through a transfer switch either from the 480V motor control center normal bus or from a separate reserve transformer.

The 480 volt switchgear consists of a metal-clad assembly of low voltage large air circuit breakers which will be used as starters for motors larger than 200 hp. Switchgear will be bus connected to the auxiliary transformer.

17.8.3 Systems and Components of 55 MW Plant.

Most, but not all, electrical components for the 55 MW units will be larger in size than those for the 25 MW plant, generally in proportion to their size. The auxiliary power system will not only be larger in capacity but also will have more components. This equipment will be all indoor except for the auxiliary power transformer which will be only slightly larger physically.

The size of some electrical components are not a function of the size of the units, such as communications, protection, control, monitoring, and alarm systems and will have the same impact for both sizes of generating units.

The physical size of the high voltage switchyard and its apparatus is mostly a function of voltage. The 55 MW generating units will have a higher transmission

voltage such as 138 kV instead of the 69 kV level proposed for the 25 MW plant. Higher voltage requires greater spacing for the air insulated conductors used for transmission of power. To obtain proper clearances, taller structures and a larger area is needed for the switchyard at the higher voltage. A slightly higher visual impact will result.

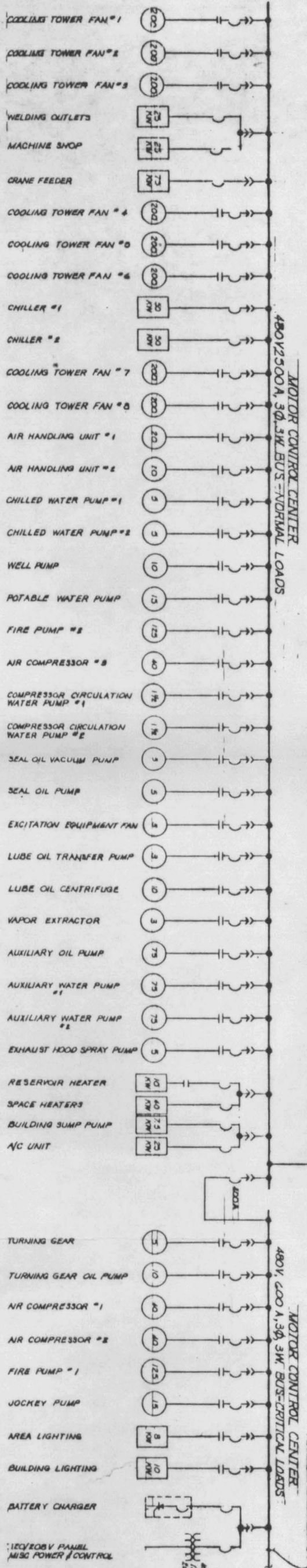
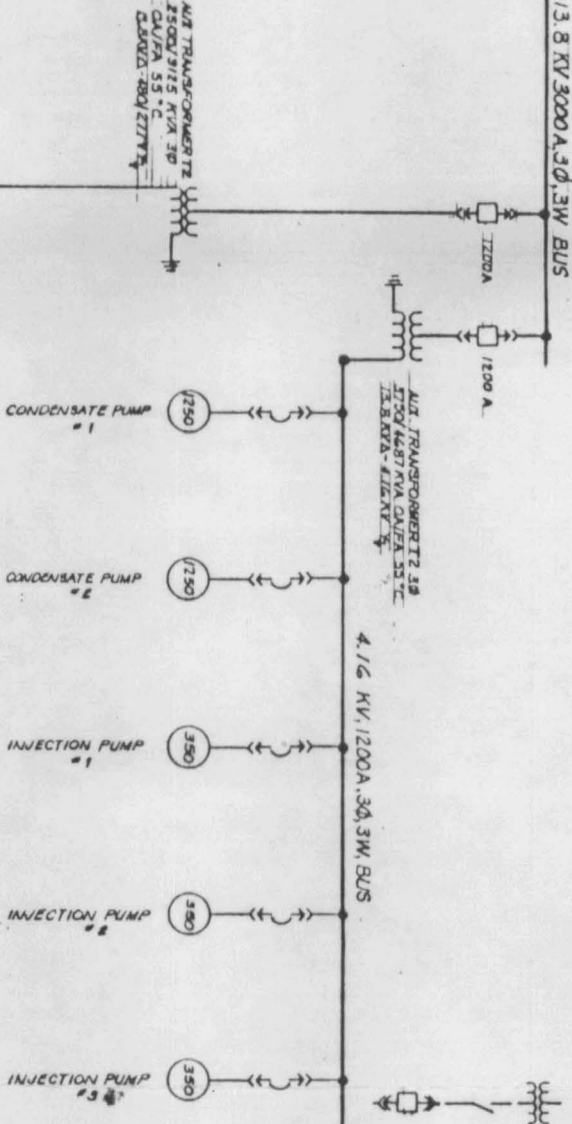
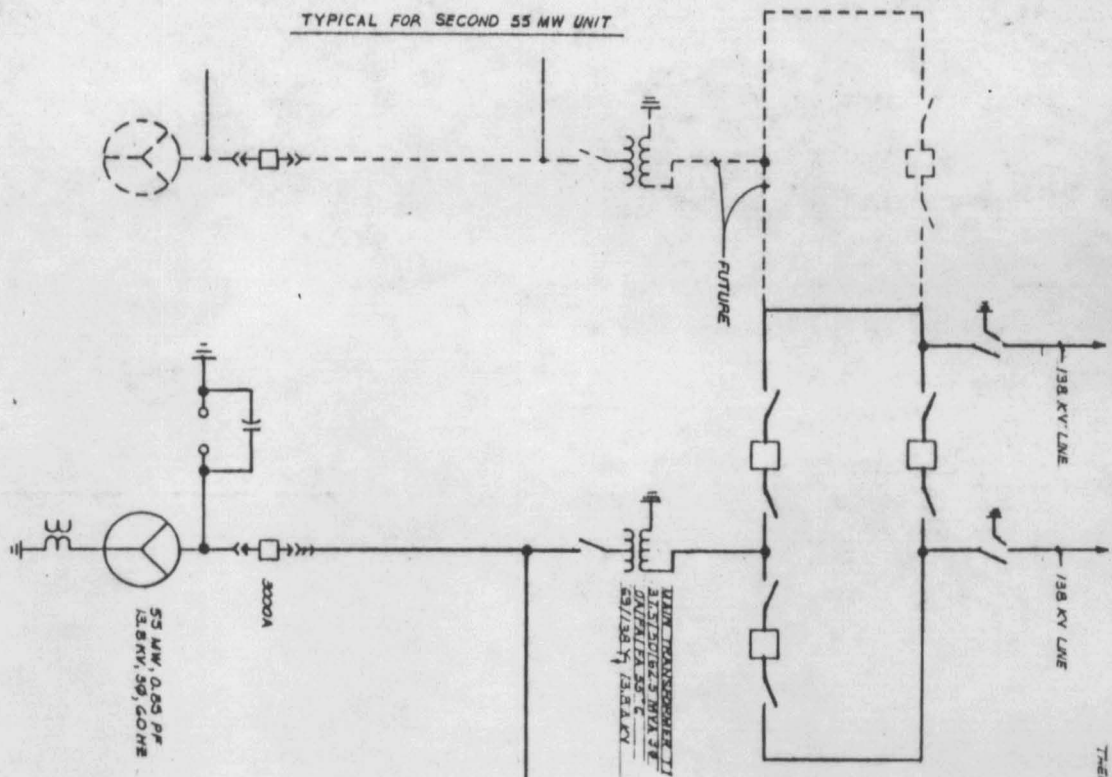
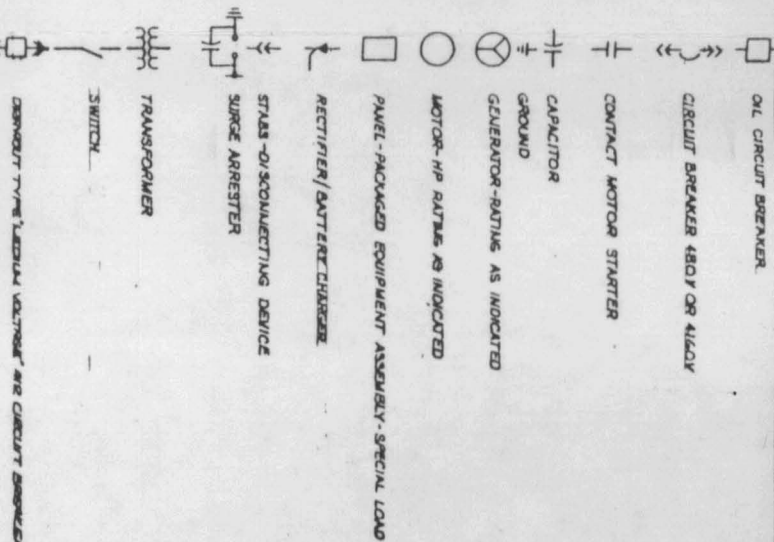
A second generating unit will double the amount of generating equipment and will approximately double the size of the building. The high voltage switchyard will have one more 138 kV circuit breaker and related buses added for the second unit, approximately a 1/4 increase in amount of equipment. (See Drawing No. E-08-001 for single line diagram of 55 MW plant).


17.9 Energy Conversion (Process) Systems

The following paragraphs provide elementary descriptions of the steam cycle, circulating water systems, steam condensate system and exhaust of noncondensable gases. Taps will be located on these piping systems in order to withdraw samples of steam, condensate, noncondensable gases and cooling water. A technical laboratory organization will be retained to take these samples and perform chemical analysis as required.

NOTE:
LINES INITIALLY MAY BE OPERATED AT 69 KV.
IF TRANSMISSION IS EXTENDED TO OTHER ISLANDS,
THEN VOLTAGES MAY BE INCREASED TO 138 KV.

LEGEND



										<div><div></div><div>ROCKWELL ENGINEERING CO., INC. SHELTON, CONNECTICUT 111 WEST STREET NEW HAVEN, CONNECTICUT 06511</div></div>										TRUE/MID-PACIFIC VENTURE										35 MW GEOTHERMAL POWER PLANT SHELTON, CONNECTICUT CONCEPTUAL STUDY SINGLE LINE DIAGRAM POWER PLANT AND SUBSTATION									
										APPROVED										DATE																			
BY: <u>TEL. ONE</u>										DATE: <u>6-21-91</u>																													
BY: <u>HLR</u>										DATE: <u>APPROVED: FIVE</u>										JOB NO. S-81010																			
REFERENCE DRAWINGS										REVISION										REVISION																			
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17.9.1 Steam Cycle

Steam from the gathering systems is supplied to the plant steam line at the boundary. A steam line pressure relief system will be installed for emergency shutdown of the turbine-generator. Steam is piped to the turbine, and in smaller quantities, to the turbine gland seals, first noncondensable gas ejector and second stage noncondensable gas ejector. Turbine steam is exhausted at 4 in. Hg Abs. downward to the shell side of a surface condenser. Cooling water flow through the horizontal condenser tubes is in a multi-pass arrangement.

(12.5 MW Capacity) - Discharge from the stage (main condenser) enters an intercondenser where noncondensable gases are drawn off by a steam jet ejector discharging to the atmosphere through a silencer. A second stage steam jet ejector is provided which exhausts to atmosphere through the same silencer. See Drawing No. E-03-001 for Flow and Control Diagram.

(55 MW Capacity) - Discharge from the first stage (main condenser) steam jet ejector enters an intercondenser where noncondensable gases are drawn off by a second steam jet ejector discharging to the after-condenser.

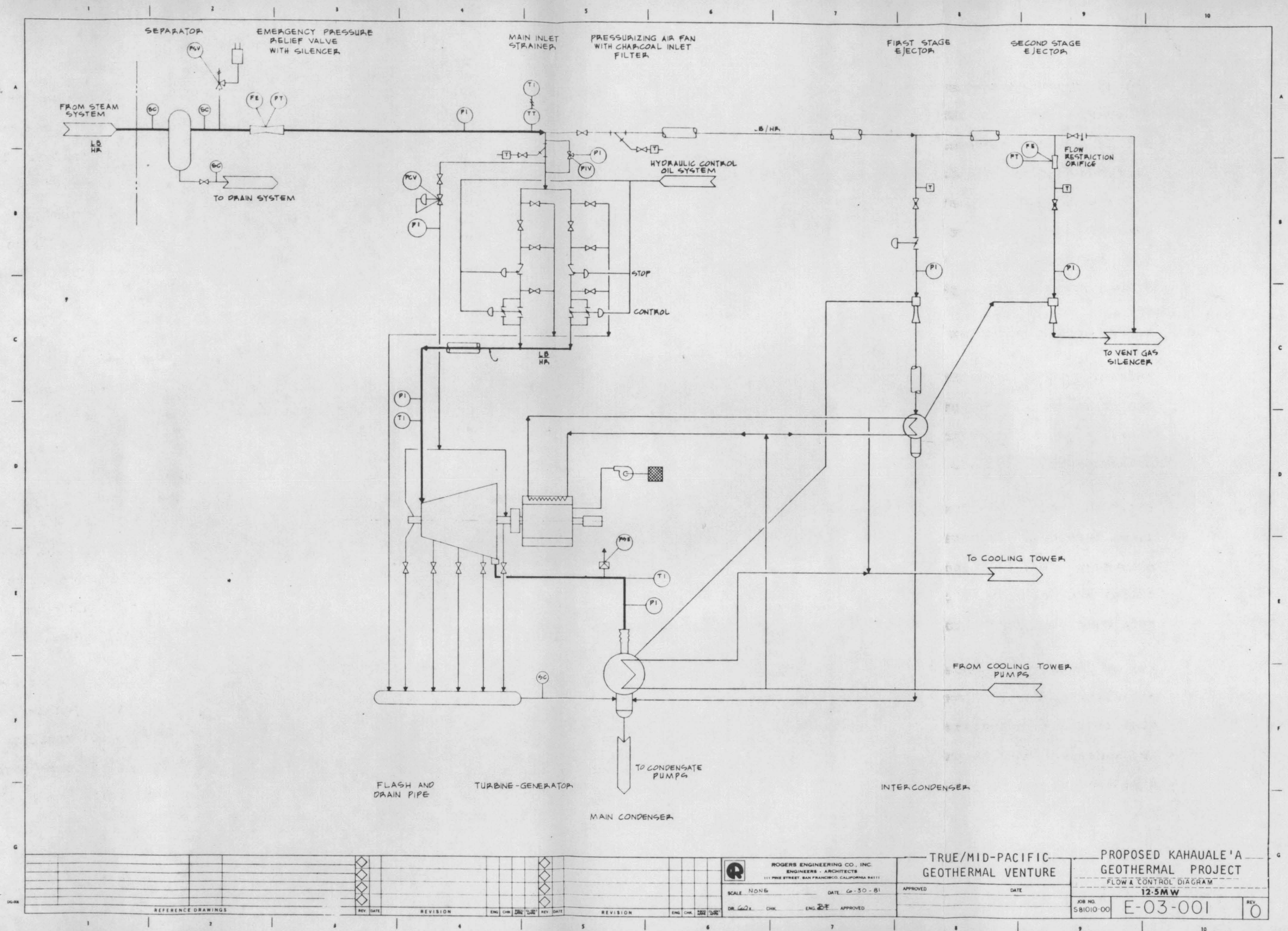
The after-condenser gas and uncondensed steam is discharged to a gas abatement unit which converts the H_2S in the noncondensable gas to sulfur. This bulk sulfur by-product should find a market in the agriculture and sugar industries of Hawaii. The other nominal end-products of the process will be reinjected with the spent brine. (See Drawing No. E-02-001 for flow diagram of power plant).

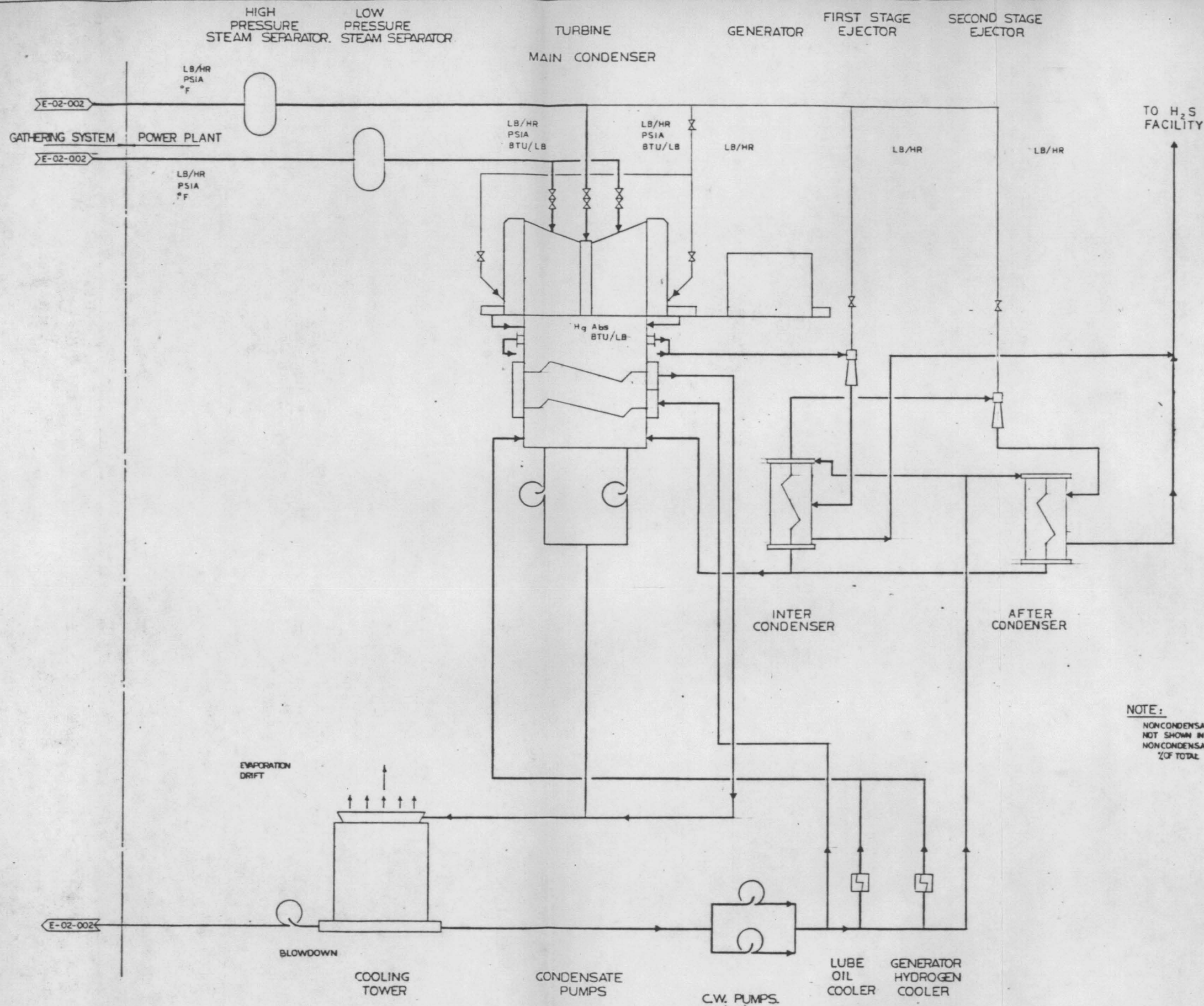
17.9.2 Steam Condensate System

Surface type condensation equipment was selected for the concept design to permit extraction of the noncondensable gases for environmental clean up by chemical or incinerator process.

(12.5 MW Capacity) - Condensate from the intercondenser flows by vacuum pressure differential to the main condenser. Two full capacity transfer pumps (one spare) are provided to pump the condensate from the main condenser to the cooling tower basin.

(55 MW Capacity) - Condensate from the inter-condenser and after-condenser flows by vacuum pressure differential to the main condenser. Two 60% capacity transfer pumps are provided to pump the condensate from the main condenser to the cooling tower basin.





(SEE NOTE)

NOTE:
NONCONDENSABLE GASES AND AIR LEAKAGE
NOT SHOWN IN FLOW BALANCE.
NONCONDENSABLE GASES APPROXIMATELY
2% OF TOTAL STEAM FLOW.

REFERENCE DRAWINGS				REVISION				REVISION				REVISION				REVISION			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
ROGERS ENGINEERING CO., INC.				TRUE/MID-PACIFIC VENTURE				55 MW GEOTHERMAL POWER PLANT				KAHAUOLEA CONCEPTUAL STUDY				FLOW DIAGRAM			
111 PINE STREET, SAN FRANCISCO, CALIFORNIA 94111				DATE: 12-22-71				JOB NO. S-81010				E-02-001				APP.			
SCALE: NONE				DATE: 12-22-71				JOB NO. S-81010				E-02-001				APP.			
DR. S.M. CHK. DR. H. APPROVED. PDP				DATE: 12-22-71				JOB NO. S-81010				E-02-001				APP.			

17.9.3 Cooling Water System

The source of cooling water makeup is from the steam condensate.

Two 60% capacity main circulating water pumps are provided to pump cooling water from the cooling tower forebay through the main condenser, intercondenser, generator heat exchanger, lube oil cooler, air compressor cooling system, and back to the sprays in the cooling tower. These main circulating water pumps operate when the turbine-generator is operating. An auxiliary cooling water pump is provided to supply cooling water to essential heat exchangers when the turbine-generator is shut down. Cooling tower blowdown is required and is based on four concentrations of treated makeup water and discharges to a drain or percolation pond.

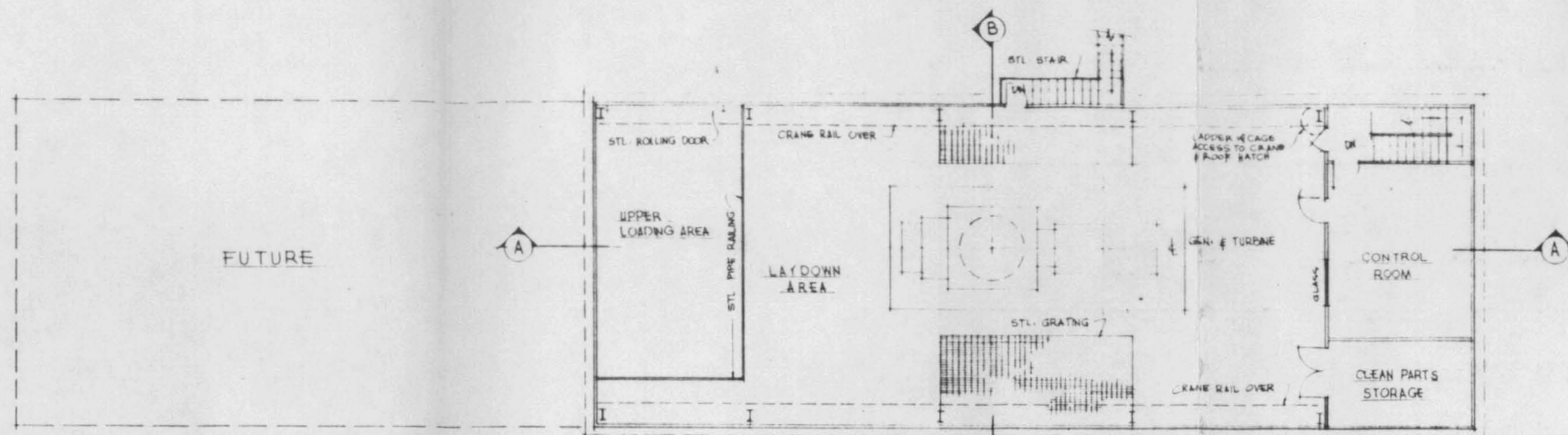
17.9.4 Non-condensable Gas System

Based on the assumption that this resource will be similar to that of HGP-A the noncondensable gases may consist of 0.2% by weight of the total steam flow. This value was used for establishing a Flow Diagram. This specification will be re-evaluated once initial production from this area is achieved and actual chemistry is known.

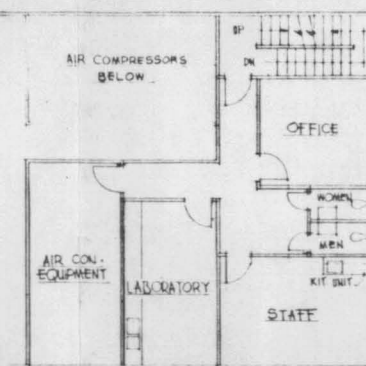
17.10 Building and Site Characteristics

17.10.1 General Description

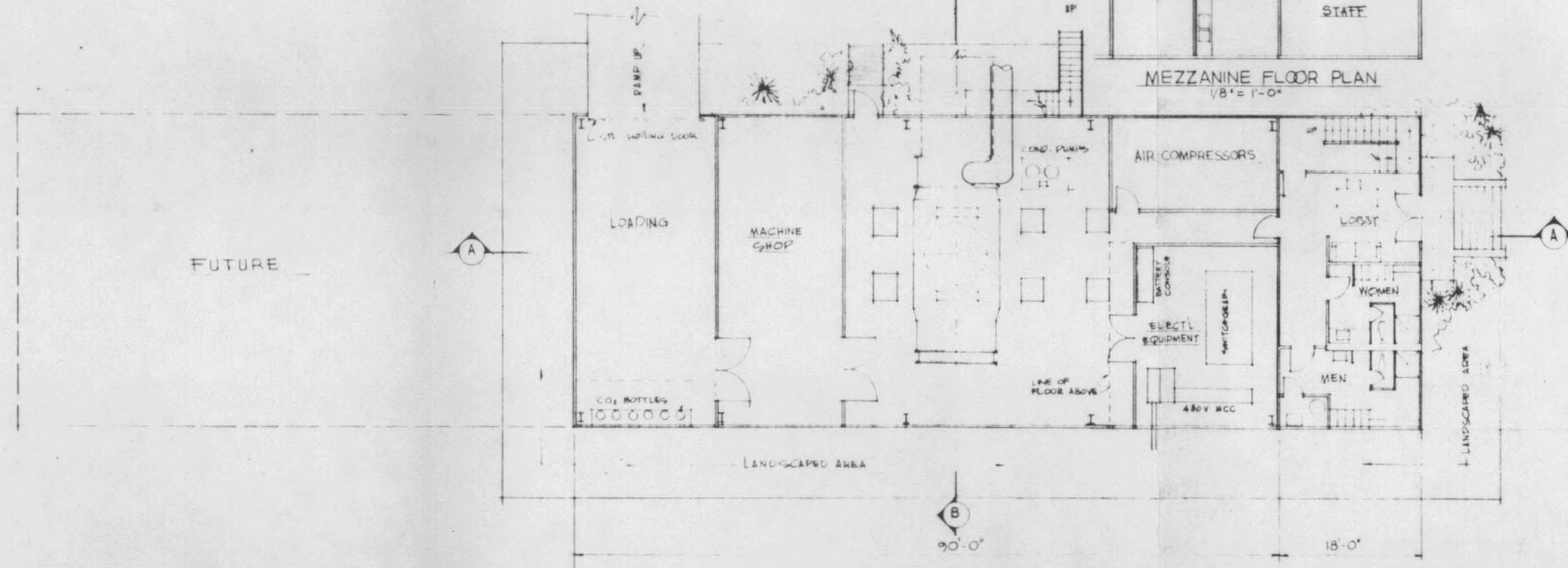
(12.5 MW Capacity) - The power plant building for a system capable of producing 12.5 MWe will comprise a two-story structure, 90'x40', fully enclosed, approximately 50' high in combination with a three-story control/administrative support module, 40'x18'. The control/administrative module will be located on the north side of the main building. The turbine-generator building and equipment arrangements and elevations are shown in Drawings No. E-04-003 and E-04-004. The ground floor slabs will be constructed on engineered fill and will assume an elevation of 3' above normal grade. The main operating floor, 22' above the ground floor, will comprise steel framing with a concrete-filled steel deck designed for 250 psi. Certain areas will have steel grating. The general structural arrangement of the main building will be rigid steel frame designed on \pm 24' bays, with girts and purlins respectively to accommodate galbestos, or similar, wall and roofing panels. A 20 ton bridge crane will be incorporated to traverse the entire length of the building, with main hook height \pm 20' above the operating floor.



OPERATING FLOOR PLAN
1/8" = 1'-0"

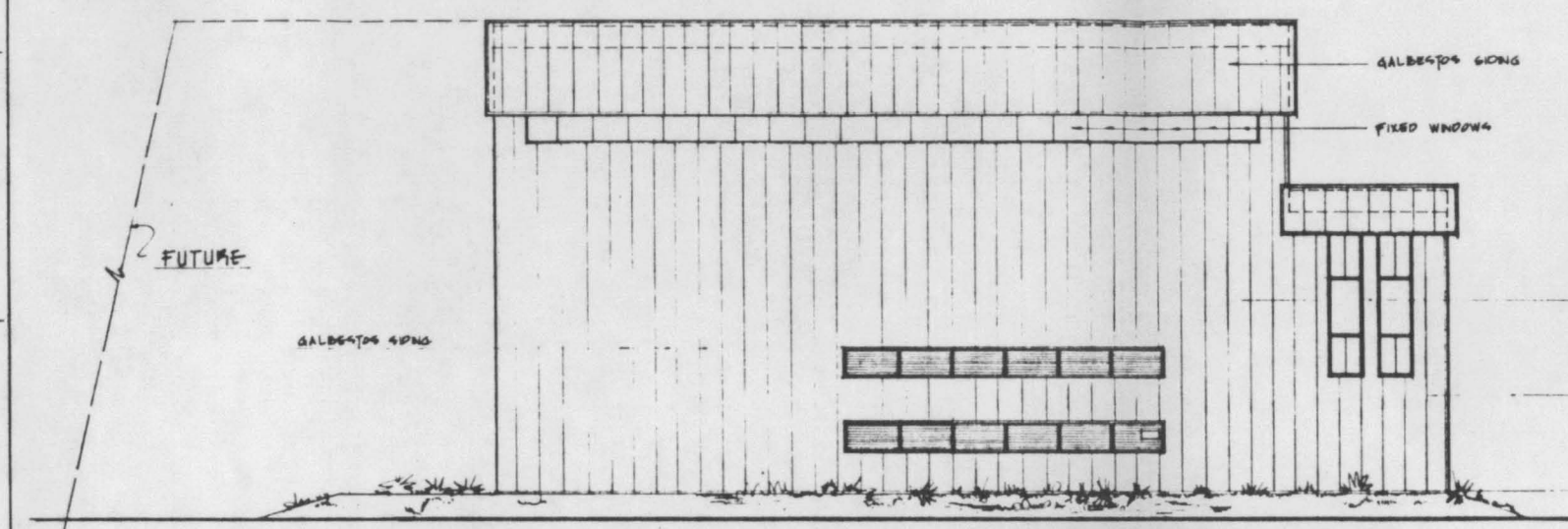


MEZZANINE FLOOR PLAN
1/8" = 1'-0"

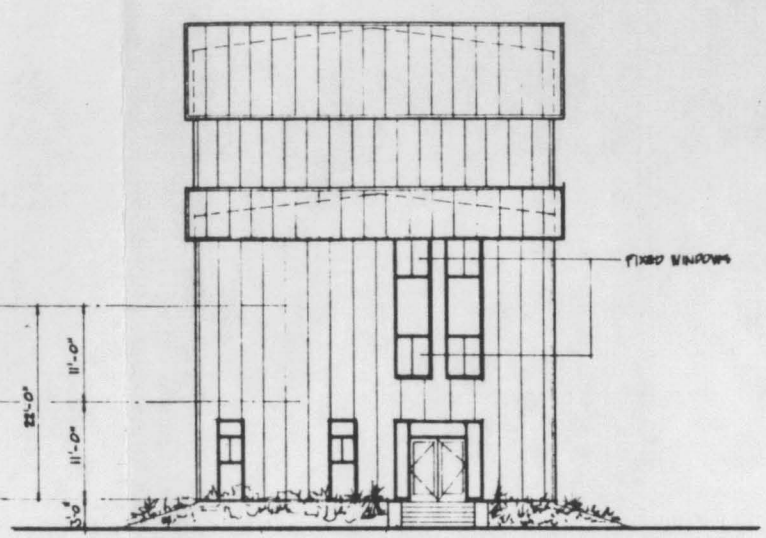


GROUND FLOOR PLAN
1/8" = 1'-0"

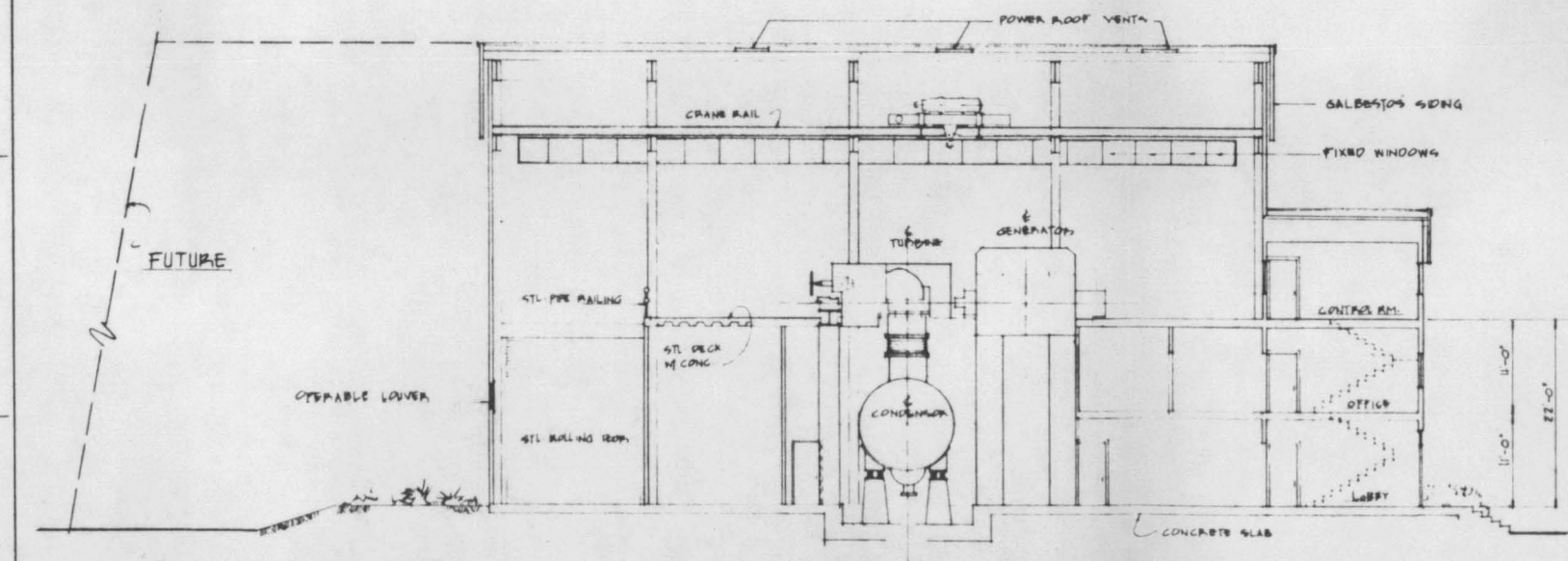
												<div><div></div></div> <div>ROGERS ENGINEERING CO., INC. ENGINEERS - ARCHITECTS 111 PINE STREET, SAN FRANCISCO, CALIFORNIA 94111</div>		TRUE/MID-PACIFIC VENTURE		PROPOSED 12.5 MW GEOTHERMAL POWER PLANT PUNA DISTRICT HAWAII FLOOR PLANS											
REFERENCE DRAWINGS												SCALE AS SHOWN		DATE 6-30-81		APPROVED		DATE		JOB NO. 581010-00		E-04-003		REV. 0			
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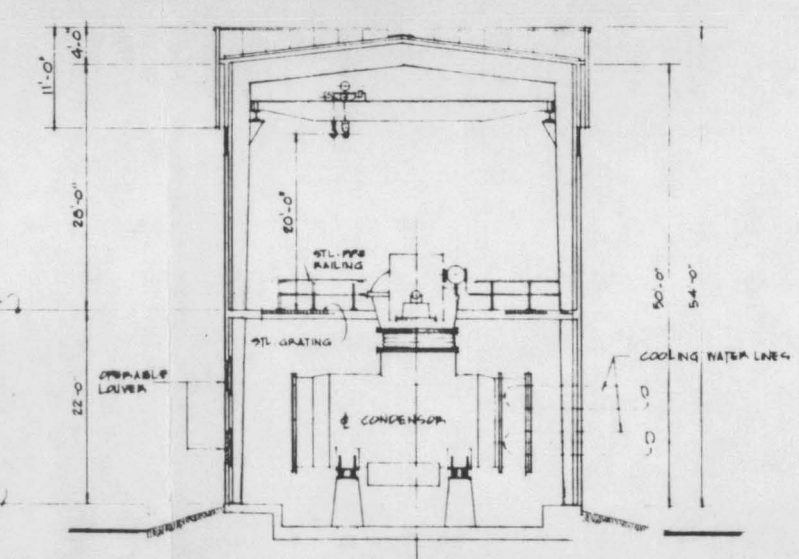
SIDE ELEVATION
1/8" = 1'-0"



FRONT ELEVATION
1/8" = 1'-0"



SECTION A-A
1/8" = 1'-0"



SECTION B-B
1/8" = 1'-0"

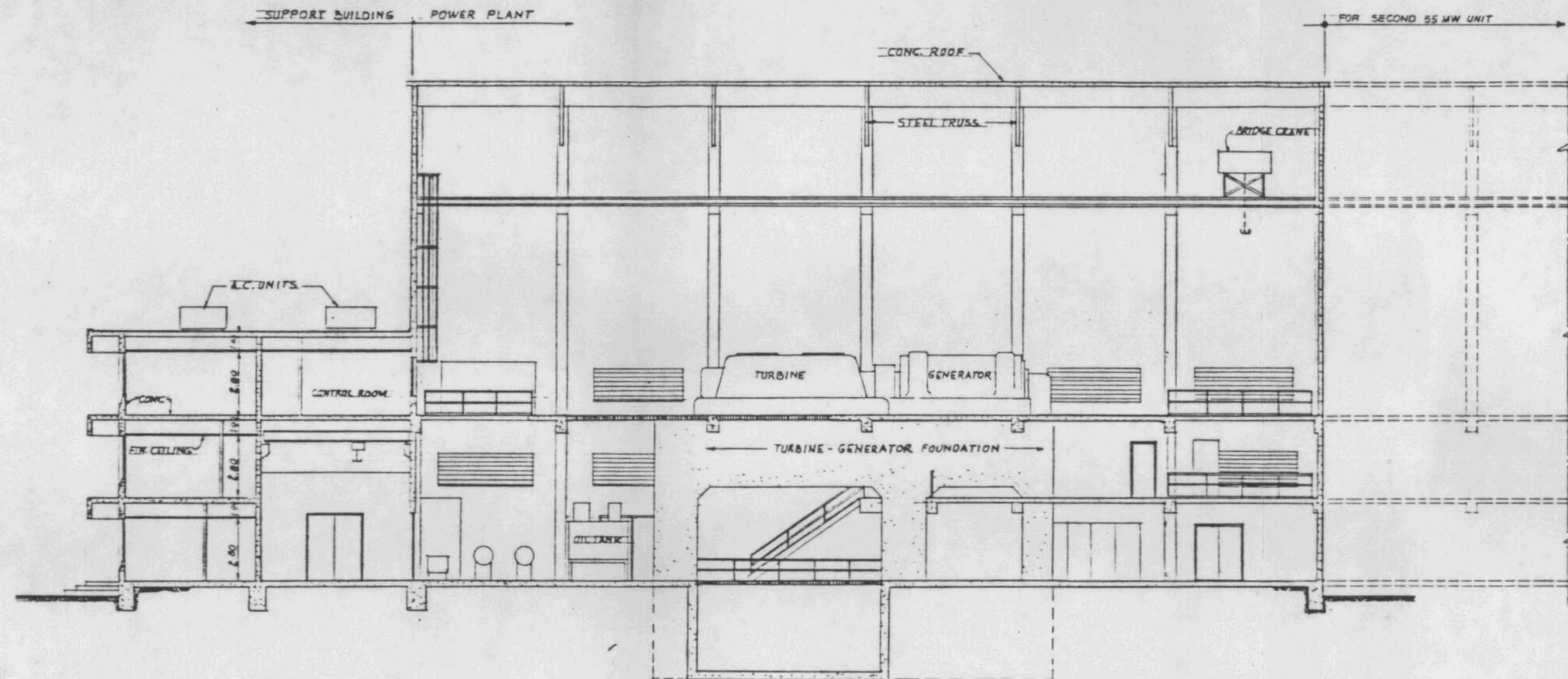
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 TRUE/MID-PACIFIC VENTURE
 SCALE 1/8" = 1'-0"
 DATE 6-30-81
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 PROPOSED 12.5 MW GEOTHERMAL POWER PLANT
 PUNA DISTRICT HAWAII
 ELEVATIONS & SECTIONS
 JOB NO. S81010-00
 E-04-004
 REV. 0

(55 MW Capacity) - The 110 MWe power plant building (2 units of 55 MWe each) will have the same basic arrangement as the 25 MWe building (2 units of 12.5 MWe each), but it will be scaled up in size substantially. The overall dimensions of the 110 MWe building will be approximately 350 ft. x 80 ft. and 65 ft. high, compared to 198 ft. x 40 ft. and 50 ft. high for the 25 MWe building.

The development of 110 MW of production capacity will be in two stages, with one complete 55 MWe unit first, followed by a second 55 MWe generating unit as an extension of the first building.

A transverse section of the 110 MW building is shown in attached Drawing No. E-80-005. The six bays to the right of the control room comprise the "Power Building" and contain all the major mechanical and electrical equipment. The right end wall of this section will be built so it can be removed when the second 55 MWe unit is added. The lower portion of the structure, on the left, is the "Support Building" -- a three level structure which contains administrative offices, the main control room, and most of the storage and maintenance facilities. The addition of the second 55 MWe unit will involve only the addition of a second "Power



TRANSVERSE SECTION 'A-A'
SCALE 1/4" = 1'-0"

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Building", or a duplication of the full height section on the right.

The turbine-generator pedestals for the 55 MWe units will extend approximately 25 feet below ground level to allow space for the main condensor. The "hot wells" for the main condensate pumps will extend further to about 33 feet below ground.

Consideration will be given to incorporating water catchment systems at each power plant site.

17.10.2 Ground Floor Area

The ground floor of the plant building proper will accommodate the following areas and major equipment:

- (1) Loading and Unloading
- (2) Machine Shop
- (3) Main Condenser
- (4) 13.8 kV Volt Switchgear
- (5) 480V Motor Control Center
- (6) Air Compressors
- (7) 69kV Switchgear Control Panel

The loading area located at the west end will effect access via a 14' x 16' rolling steel door at the north-west corner of the building.

17.10.3 Operating Levels

The operating level will accommodate the following areas and equipment:

- (1) Turbine-Generator
- (2) Lay Down Area
- (3) Clean Parts Storage

A concrete pedestal on rigid mat foundation will support the turbine-generator and main condenser units. The pedestal will be of ample rigidity such that no resonance in the natural frequency of the pedestal foundation and the turbine-generator unit will occur.

To suit the functional requirements of the bridge crane in connection with turbine-generator maintenance and access to the lay down area, the ground floor loading area will be open for the full height of the building and open to the operating floor.

Fixed windows will extend the full length of the main building on the upper east and west walls. The plant generated heat will be dissipated using a system of operable wall louvers in conjunction with open steel grating at the operating level, and roof mounted motor-operated discharge fans.

17.10.4 Control/Administrative Modules

The ground floor of the control/administrative module will accommodate the following areas:

- (1) Main Entrance/Reception Lobby
- (2) Men's and Women's Restrooms
- (3) Janitor Supply Room

The second level (mezzanine) of the control/administrative module will accommodate the following areas:

- (1) Administrative Office
- (2) Staff Room
- (3) Rest Rooms
- (4) Laboratory)
)
 A/C Equipment)

These areas encroach upon the Main Building, effecting a mezzanine between ground floor and operating floor.

The upper floor of the control/administrative module accommodates the Control and Clean Parts Storage.

A staircase adjoining the lobby will effect access between the floors of the control/administrative areas and the floors of the main plant building. A second stairway located on the west side of the operating floor will permit exit from upper floor areas.

17.10.5 Environmental Control

Instrumentation equipment enclosures, switchgear room and associated electrical equipment, and enclosed personnel areas will be air conditioned and slightly pressurized to maintain a positive air flow of clean filtered air from the equipment and personnel areas to the exterior.

17.10.6 Plant Site Perspectives

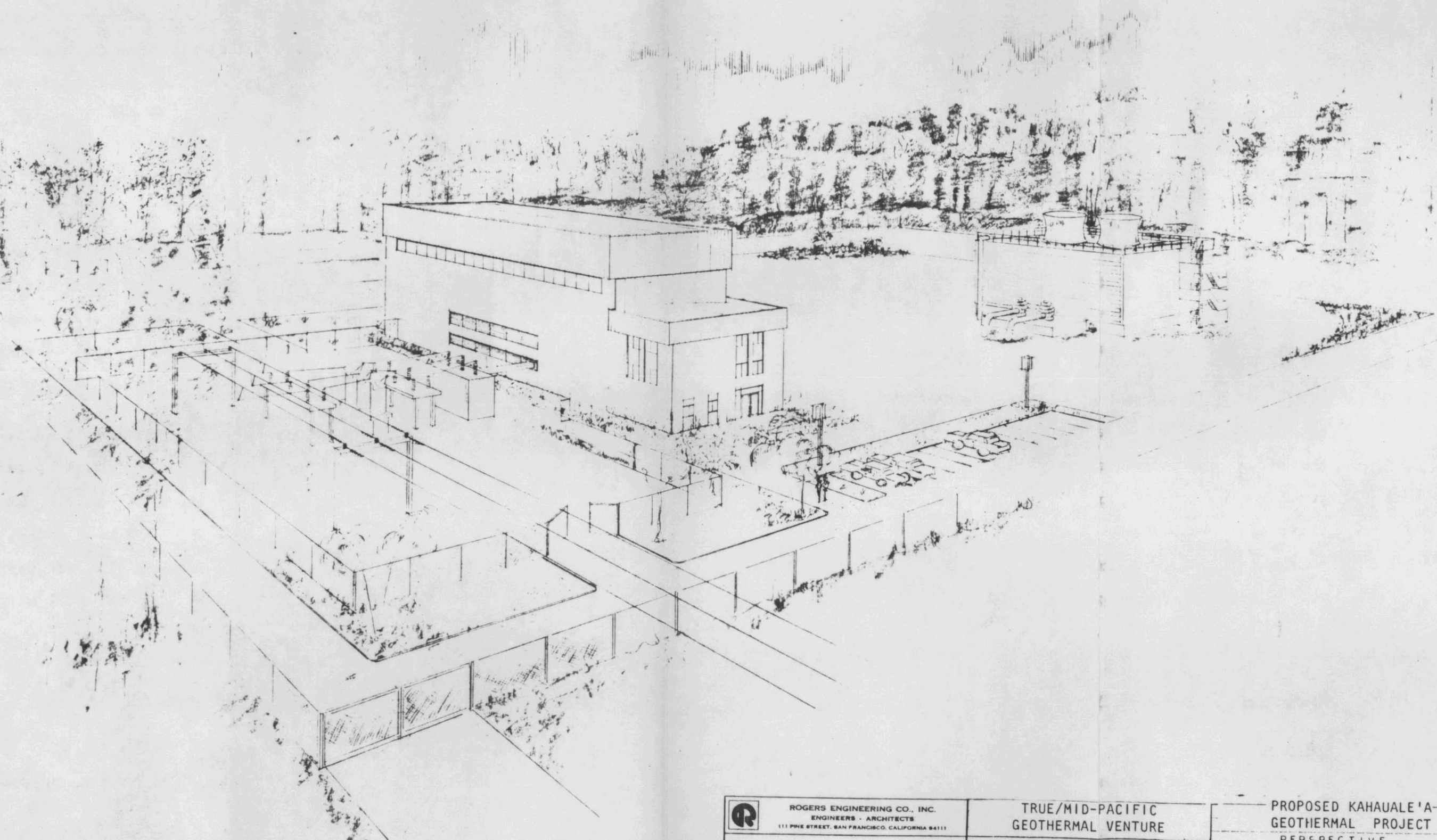
(25 MW Capacity) - A site plan perspective for a 25 MW plant is contained in Drawing No. E-00-001. In addition to the power plant building the site will contain a switchyard, cooling tower, sumps, silica drop out ponds, perimeter roads and fence and parking area.


(110 MW Capacity) - The only significant difference in the siting and arrangement of the 110 MWe plant as compared to the 25 MWe plant is in the size. The 110 MWe plant site will occupy approximately 15 acres, compared to about 7 acres for the 25 MWe plant. See Drawing No. E-80-008 for site perspective of a 110 MW plant.

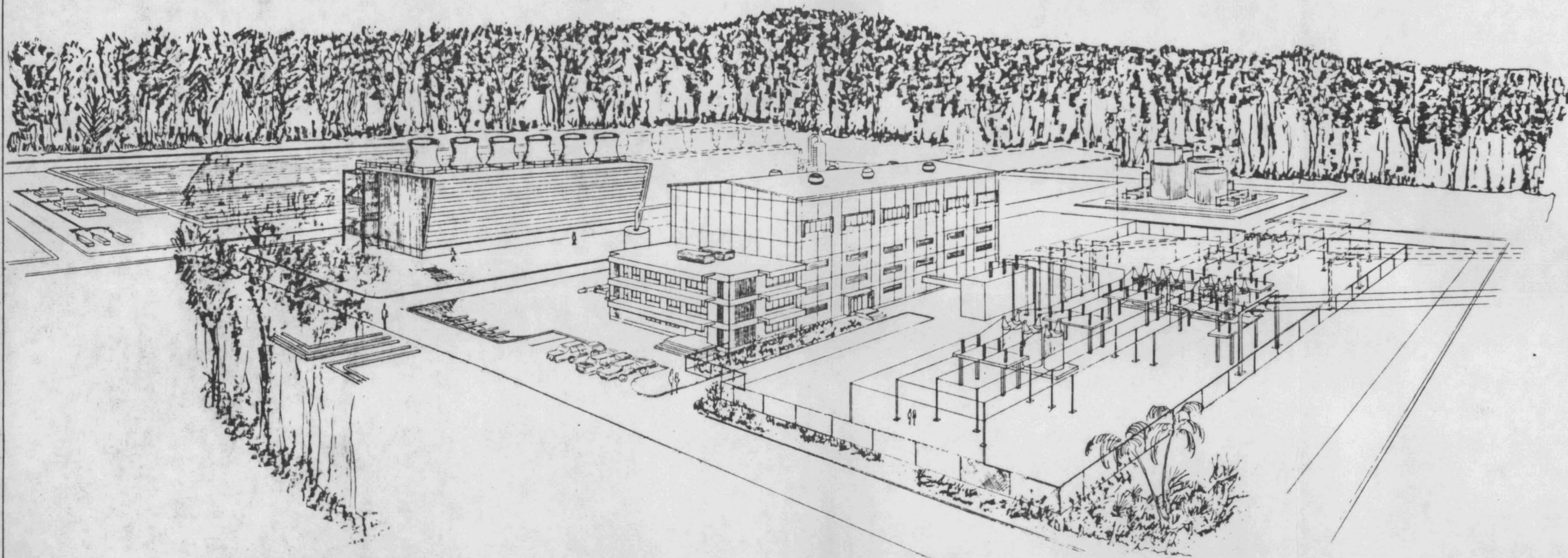
18.0 Electrical Transmission System

18.1 General

The planning and design of an electrical transmission



		ROGERS ENGINEERING CO., INC. ENGINEERS - ARCHITECTS 111 PINE STREET, SAN FRANCISCO, CALIFORNIA 94111	
SCALE <u>NONE</u>		DATE <u>6-30-81</u>	
DR. <u>CHK</u> ENG. <u>APPROVED</u>		APPROVED <u>DATE</u>	
		TRUE/MID-PACIFIC GEOTHERMAL VENTURE	
		PROPOSED KAHUALE'A GEOTHERMAL PROJECT PERSPECTIVE 12.5 MW	
		JOB NO. S81010-00	REV. <u>0</u>
		E-00-001	



REFERENCE DRAWINGS				REVISION				REVISION			
1	2	3	4	5	6	7	8	9	10		



ROGERS ENGINEERING CO., INC.
ENGINEERS - ARCHITECTS
131 PINE STREET, SAN FRANCISCO, CALIFORNIA 94111

TRUE/MID-PACIFIC VENTURE

SCALE

DATE 12-29-81

APPROVED

DATE

DR

CHK

ENG

APPROVED

100

55MW GEOTHERMAL POWER PLANT
KAHAUWALE CONCEPTUAL STUDY

PLANT PERSPECTIVE

JOB NO.
S 81010

E-80-008

REV.

system to transport and control the amount of potential generating capacity estimated for this project will be accomplished incrementally as generating capacity is proven and the market to use the power is established. Such planning must address the transport of power within the project area as well as to the nearest connecting point of HELCO's existing or future transmission system that can accommodate the power being generated. In addition, planning for the system which may be required to export bulk power must consider the potential of all geothermal development areas in relation to the route of the proposed undersea cable, its land terminus on the Big Island (the alternating/-direct current conversion station), and its overland route to the geothermal resource development areas.

18.2 Initial Requirement

The near term projection for this project (through 1988), subject to obtaining a contract from HELCO, indicates the requirement for a transmission system capable of transporting up to 25 MW of power. The point of interconnection with HELCO's electrical system is the high voltage terminals of the power plant step-up transformer. The related switchyard, metering facilities and transmission lines for interconnecting with

the HELCO system will be the responsibility of HELCO. Within the Kahauale'a parcel, it is planned that the transmission lines will be routed along the access roads to the Belt Highway. The line capacity required for 25 MW is 69 kV. HELCO would have to extend a 69 kV line from an existing or new substation into the property to the bus bar connection at the power plant. (See Figure 15 for transmission line planning data.)

19.0 MARKETING OF RESOURCES

Within the scope of this project, the principal market for discovered geothermal resources is for generation of electrical power. Direct use applications will be promoted and developed as may be feasible in coordination with state and county agencies and the local communities.

The electrical power base load market potential on the Big Island is currently, and for the near future, limited to approximately 25 MW based on HELCO's projections. Beyond this requirement, the development of a market depends primarily on the initiation and completion of the undersea cable and/or a major expansion of the power demands on the Big Island to meet the needs of new energy intensive industries.

TRANSMISSION LINE PLANNING REQUIREMENTS

<u>Production Capacity</u>	<u>Line Capacity</u>	<u>Type</u>	<u>Poles Height</u>	<u>Spacing</u>	<u>No. of Circuits</u>	<u>Right of Way</u>
25MW	69 KV	Wood	67'	600'	Single	25'
55-225 MW	138 KV	Steel	90'	800'	Double*	75'

*Double circuited and double bundled to accommodate 12 lines.

Appendix A
Extracts of Regulations
Applicable to Development Plan

HRS, Title 13, Subtitle 7, Water and Land
Development; Chapter 183, "Rules on Leasing and
Drilling of Geothermal Resources."

Rule 183-3: Mining lease means a lease of the right to conduct geothermal operations on State lands or reserved lands to discover, develop, produce and utilize geothermal resources therein.

Rule 183-19: Provides that the Board of Land and Natural Resources may grant geothermal mining leases conveying to the lessee the exclusive right to drill, discover, develop, operate, utilize and sell geothermal resources in accordance with terms and conditions set by the Board.

Rule 183-20: All State and reserved lands shall at the discretion of the board be considered available for geothermal mining lease.

Rule 183-38: Each application for mining lease must include a "brief preliminary proposal of a plan for geothermal exploration and development and an assessment of the environmental impact from the geothermal resource exploration and development."

Prior to the Board's decision on the application, the Board may require "full evaluation of the potential effect of geothermal exploration and development on the environment, fish and wildlife resources, aesthetics, population and other resources". This evaluation "will consider the potential impact of possible geothermal development and utilization including the construction of power generating plants and transmission facilities."

Rule 183-52: "The lessee shall be entitled to use and occupy only so much of the surface of the leased lands as may be required for all purposes reasonably incident to exploration for, drilling for, production and marketing of geothermal resources and associated by-products produced from the leased lands including the right to construct and maintain thereon, all works, buildings, plants, waterways, roads, communications lines, pipelines, reservoirs, tanks, pumping stations or other structures necessary to the full enjoyment and development thereof, consistent with an approved Plan of Operation."

Rule 183-54(g): The lessee shall commence mining operations on the leased lands within three years from the date of the execution of the lease or upon expiration of any research period approved by the Board.

Rule 183-55: "A lessee shall not commence operations of any kind prior to submitting to the Chairman for Board approval, a Plan of Operations".

Rule 183-65: Prior to drilling operations (including modifying, modifying the use of, or abandoning of any well) the operator shall file with the Chairman for approval an appropriate application for permit to perform such work, or a supplementary application for any contemplated changes thereto.

HRS, Title 13, Subtitle 1, Administration,
Chapter 2, Conservation District Use.

Provides that applications for change in the use of conservation district land shall be submitted to the Department for approval prior to initiating any work within the District; that all applications shall be subject to applicable Federal and State statutory requirements relating to environmental impact; that every application shall be accompanied by a preliminary and or final plan together with other applicable information as determined necessary by the Chairman.

Provides that deviation from any of the conditions provided for in the regulation may be considered by the board only when supported by satisfactory written justification that such deviation (1) is necessary because of the lack of practical alternatives, (2) will not result in significant adverse impacts to the environment, (3) does not conflict with the objective of a subzone and (4) is not inconsistent with the public health, safety or welfare.

APPENDIX B

CHECK LIST OF SELECTED DEVELOPER/OPERATOR ACTIONS/DECLARATIONS REQUIRED BY HRS, TITLE 13, SUBTITLE 7, WATER AND LAND DEVELOPMENT; CHAPTER 183, "RULES ON LEASING AND DRILLING OF GEOTHERMAL RESOURCES"

1. Establish Eligibility to Hold Geothermal Mining Lease
(Rule 183-3 and 183-21)

- True Geothermal Energy Company is registered in the State of Hawaii as partnership authorized to conduct business in Hawaii; Not in arrears in taxes, rents or obligations to the State.
- Mid-Pacific Geothermal, Inc., is registered as a foreign corporation, not in arrears in taxes, rents, or obligations to the State.
- Officers executing sub-lease agreement authorized to act on behalf of the venturers.

2. Limitations on Acreage (Rule 183-28)

- No person affiliated with the Developers/Operators holds, owns or controls land in excess of 80,000 undeveloped acres.

3. Annual Rentals (Rule 183-30)

- 1st year: In advance when lease executed
- Subsequently: Anniversary date

4. Royalties on Production (Rule 183-31)
 - Pay within 30 days after the end of each calendar month with supporting sales data.
5. Performance Board (Rule 183-34)
 - Blanket bond for \$50,000 for multiple leases. Check made payable to State of Hawaii as approved by DLNR.
6. Liability Insurance (Rule 183-35)
 - Public liability and property damage insurance from company authorized to operate in Hawaii in amounts to be determined by the Board.
 - Supplementary coverage for explosion, collapse and underground hazards prior to drilling operations. Special endorsement requirements apply.
7. "Hold Harmless" Agreement (Rule 183-36)
 - Mining Lessee shall expressly agree to terms of this agreement.
8. Regulate public access and vehicle traffic and operate to protect human life, wildlife and property (Rules 183-53 and 183-55)

- Security gate to project area will be established on access road; normal safety practices will be observed in all operations; landowner will institute land/wild life management program upon opening property with access road.
9. Surface rights and obligations (Rule 183-51)
- Prospective mining sub-lessee has negotiated sub-lease agreement with land owner on surface rights and obligations.
10. Designation of local representative empowered to receive service of civil or criminal process and notices and orders of the chairman (Rules 183-54(e) and Rule 183-64).
- To be designated by Developers/Operator
11. Designation of Operator other than lessee of the geothermal mining lease (Rule 183-54(f))
- True Geothermal Energy Company of Casper, Wyoming is designated as the "Operator" for the mining operations as may be authorized in the State geothermal mining lease.
12. Lessee shall not commence operations prior to submitting to the chairman for approval, a "plan of operations" (Rule 183-55).

- The Developers/Operator in coordination with the landowner have prepared the "Master Plan for Development" for the Kahauale'a geothermal project to satisfy this requirement.

13. Operator is required to file with the chairman an application for permit (\$100 non-refundable filing fee) to drill; to be acted upon with 60 days (Rule 183-65 and 183-67).

- Permit applications will be filed for drilling of 12 exploration or development wells at selected drilling sites to develop resources sufficient to supply a 25 MW power plant.

14. Operator is required to file with the chairman an indemnity bond (\$50,000 each well, or \$250,000 for any number of wells) to protect the interests of the State (Rule 183-68).

15. Reports to be filed (Rule 183-85)

- The Operator will file the required reports within 6 months after completion of the well activity on which a report is required.